NBSIR 78-1468-1

Committee on the Challenges of Modern Society Rational Use of Energy Pilot Study Modular Integrated Utility Systems Project Final Report

VOLUME 1 DESCRIPTION, ACTIVITIES AND PRODUCTS

hudmius
MODULAR INTEGRATED UTILITY SYSTEMS
improving community utility services by supplying electricity, heating, cooling, and water/ processing liquid and solid wastes/ conserving energy and natural resources/ minimizing environmental impact

Prepared by:
U.S. Department of Commerce
National Bureau of Standards
Center for Mechanical Engineering and Process Technology
Washington, D.C. 20234

June, 1978

Prepared for:
U.S. Department of Housing and Urban Development
Division of Energy, Building Technology and Standards
Office of Policy Development and Research
Washington, D.C. 20410

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COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY RATIONAL USE OF ENERGY PILOT STUDY MODULAR INTEGRATED UTILITY SYSTEMS PROJECT FINAL REPORT

VOLUME 1 DESCRIPTION, ACTIVITIES AND PRODUCTS

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, ***Secretary***
Dr. Sidney Harman, ***Under Secretary***
Jordan J. Baruch, ***Assistant Secretary for Science and Technology***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

FOREWORD

The Committee on the Challenges of Modern Society - Modular Integrated Utility System (CCMS-MIUS) Project was established by NATO CCMS in 1974 as a result of strong international interest in improving methods for providing better utility services to communities. The CCMS-MIUS Project is a sub-project of the pilot study Rational Use of Energy. Both are piloted by the United States.

The CCMS-MIUS Project has been carried out under the leadership and sponsorship of the United States Department of Housing and Urban Development (HUD),Division of Energy, Building Technology and Standards, Office of Policy Development and Research. The National Bureau of Standards provided technical support to HUD.

The major objective of this project was to develop and implement a mechanism for the exchange of technical information on Modular Integrated Utility Systems (MIUS) Type of Projects in the participating countries. During the project several important products were developed, including a glossary of special terms, a catalog of project descriptions and a standard methodology for reporting the performance of MIUS Type of Projects.

This project marks the beginning of a significant exchange of information. Further work is required to develop the mechanism more completely and bring about actual exchanges of technical information. This is reflected in the recommendations of the CCMS-MIUS Project committee at its last meeting July 12-14, 1977 in Turin.

This report is in two volumes. The first volume includes a chronology and description of the project, its activities, and products, and a copy of each product developed. Volume two includes the minutes of the CCMS-MIUS Project meetings.

CONTRIBUTING STAFF

The U.S. was the lead country and the U.S. Department of Housing and Urban Development (HUD) served as the lead agency for the CCMS-MIUS Project. HUD sponsored and directed the U.S. participation and effort under the leadership of J.H.Rothenberg, HUD-MIUS Program Director. The National Bureau of Standards in providing technical support to HUD on the HUD-MIUS Program performed the duties of Secretariat and chaired the semi-annual committee meetings.

Countries and individuals who contributed to the project are hereby acknowledged:

<u>Lead Country</u>
United States

<u>Head of U.S. Delegation</u>
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<u>Secretariat</u>

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<u>Subcommittee Chairmen and Members</u>

Refer to paragraph 2.6.

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APPENDICES

EXECUTIVE SUMMARY

1. The Committee on the Challenges of Modern Society - Modular Integrated Utility Systems (CCMS-MIUS) Project held its fifth and final meeting in Turin, Italy, July 12-14, 1977. Sixteen experts from seven NATO countries (Belgium, France, Federal Republic of Germany (FRG), Italy, Netherlands, United Kingdom and United States) participated. The project had its first meeting in Brussels at NATO headquarters on April 10-11, 1975. Forty-three experts from 12 countries participated in the project during its 2-1/2 year period.

2. From its beginning, the project commanded a strong interest among the participating NATO and Non-NATO countries. This was demonstrated by the excellent contributions to the International Project Catalog and the strong recommendations by the committee that the project's work continue. These recommendations are contained in paragraph 1.2. The project's success and the strength of the recommendations for its continuation reflect the MIUS concept's potential to satisfy critical needs mutually shared by the participating countries.

3. The MIUS approach recycles energy by packaging into one processing plant as many as six utility services for community development. It provides electricity, space heating and water heating, air conditioning, solid waste processing, wastewater treatment and residential water purification. Conventional methods of generating electricity convert about 35% of the source energy input to electrical output. The remaining 65% is rejected to the atmosphere or bodies of water in a manner that optimizes the electrical conversion process. MIUS theoretically can recover better than half of this rejected energy and use it for space heating/air conditioning, water heating and to improve wastewater treatment efficiency. An additional 5-10% fuel savings can be achieved by recycling solid waste for its energy content.

4. The MIUS concept offers an opportunity for communities to conserve natural resources, reduce energy consumption and minimize environmental impact while obtaining the same utility services which would traditionally be provided by separate facilities. It permits more flexible land use patterns and reduces the infrastructure requirements for wastewater treatment. The MIUS can reduce a community's vulnerability to loss of electrical service. This was demonstrated during a recent New York blackout (July 1977) when an independent total energy plant continued to serve a community of high rise apartments. If grid connected, a MIUS can also serve to assist the utility companies by performing the function of a peaking plant.

5. The major product of the CCMS-MIUS Project is an "International Project Catalog", which contains over 200 project descriptions of MIUS Type of Projects from twelve countries.

6. Included in this report are a standard methodology for measuring the performance of MIUS Type of Projects (integrated utility systems) and the reporting and taking of data, research needs in MIUS Type of Projects, a glossary of special terms unique to MIUS, and recommendations for future activities.

7. The CCMS-MIUS Project Committee at its final meeting recommended that its international work continue and that further investigation of the institutional problems associated with the implementation of MIUS Type of Projects be carried out. It was also recommended that more information about the benefits of MIUS Type of Projects (integrated utility systems) over conventional utility systems be provided for the public, private and government sectors in the NATO countries.

COMMITTEE ON THE CHALLENGES
OF MODERN SOCIETY

RATIONAL USE OF ENERGY PILOT STUDY
MODULAR INTEGRATED UTILITY SYSTEMS PROJECT
FINAL REPORT

M.H. Nimmo
C.W. Phillips

Abstract

This report by the Committee on the Challenges of Modern Society - Modular Integrated Utility Systems (MIUS) Project includes a description of the project, its objectives, the chronology of the project, a description of its activities and products, copies of its products (appendices A-E), and minutes of its meetings. This report further discusses the progress of each activity and product and gives the committee's recommendations, which call for the continuation of the project activities.

The objectives of the CCMS-MIUS Project were to identify MIUS Type of Projects in participating countries and to develop a mechanism for transferring technical data concerning these products to experts in the participating countries. The project had its first meeting in Brussels, April 10-11, 1975 and its last meeting in Turin, July 12-14, 1977.

The project produced a glossary of special terms, a project summary form the International Project Catalog, and a list of research needs in MIUS Type of Projects. It began development of a project progress/evaluation report, a standard methodology for measuring the performance of MIUS Type of Projects and a paper on "Incentives and Barriers".

The glossary is expected to promote a greater understanding of terms unique to MIUS and the project summary form was developed to seek project descriptions for the catalog. The catalog identifies MIUS Type of Projects and the project progress/evaluation report provides progress of a project and technical information for purposes of evaluation and comparison. The standard methodology identifies the type of information required for measuring the performance of a MIUS Type of Project and the collecting and reporting of data.

Keywords: CCMS, CCMS-MIUS Project, Information Exchange, Integrated Utility Systems, International Information Exchange, MIUS, Report to CCMS Plenary

1.0 INTRODUCTION

1.1 Purpose and Contents

This report describes the Committee on the Challenges of Modern Society - Modular Integrated Utility Systems (CCMS-MIUS) Project, Rational Use of Energy Pilot Study and its purpose, activities, products, accomplishments and recommendations.

Included in the Appendices are the various products prepared by the project committee, except for the International Project Catalog, which will be published separately, a list of Research Needs in Integrated Utility Systems and minutes of the project's five meetings.

The CCMS-MIUS Project has been piloted by the U.S. under the leadership and sponsorship of the U.S. Department of Housing and Urban Development (HUD), Division of Energy, Building Technology and Standards, Office of Policy Development and Research.

1.2 Recommendations

The CCMS-MIUS Project's ad hoc committee on future activities was appointed at the project's fourth meeting to present recommendations at the fifth meeting. In consideration of several products that required additional work and several issues of importance to integrated utility systems that needed studying the ad hoc committee presented the following recommendations:

I. The CCMS-MIUS Project's _ad hoc_ committee on future activities met on Monday, July 11, 1977 and prepared its recommendations for consideration by the CCMS-MIUS Project Committee at its last meeting July 12-14, 1977. The CCMS-MIUS Project Committee approved the following recommendations:

"IIa. Whereas the CCMS-MIUS Project has completed its intended tasks and pilot operation with the submittal of its final report to the CCMS Plenary in October 1977 and;

b. Whereas the CCMS-MIUS Project has investigated the potential economics, energy-saving, and social benefits to be derived from proper applications of integrated utility systems, and;

c. Whereas the CCMS-MIUS committee through its investigations considers that the properly applied integration of utility systems, particularly through the combining of electric power generation and heating offers significant potential energy saving and economic benefits and;

d. Whereas the CCMS-MIUS Project has demonstrated the need and value of information exchange between countries on the technical, economic and institutional aspects of integrated community utility systems, the following recommendations are presented to the CCMS Plenary, that;

IIIa. Means for continuing the information exchange between countries be sought

b. Means for continuing the International Project Catalog and the exchange of data from those projects be sought

c. Means for continuing the development of the standard methodology for measuring and reporting the performance of integrated utility systems be sought

d. Means for continuing the work of the incentives and barriers committee (each nation has needs to investigate institutional barriers in its own national system).

e. A mechanism be developed for informing countries of the need to consider changes in laws and regulations to obtain the maximum economic and energy saving benefits of integrated utility systems

f. Procedures be developed whereby the services of experts be made available to assist and inform countries which request such assistance in the implementation of integrated utilities

g. Studies, investigations, demonstrations and research be carried out to further provide needed information to improve integrated utility systems. Such studies should include, but not be limited to the economic, technical, legislative management and institutional aspects.
Note: Refer to Appendix E for a prioritized list of research needs and paragraph 3.6.

h. The appropriate organizational means be determined to carry out the recommendations listed above

i. The secretariat of the CCMS-MIUS Project be requested to actively seek accomplishment of the recommendations no later than July 1, 1978 and to prepare follow up reports for the fall CCMS Plenary for at least two years."

1.3 Meetings of the Project

The CCMS-MIUS Project had its first meeting in Brussels at NATO headquarters, April 10-11, 1975. It was an organizational meeting in which the various needs in the transfer of MIUS information were identified and the tasks to help satisfy these needs begun. A summary of the five CCMS-MIUS meetings is given in Table 1. Also refer to Volume 2, Appendices F through J, for minutes of the five meetings.

TABLE 1
SUMMARY OF CCMS-MIUS
PROJECT MEETINGS

MTG #	LOCATION	DATE	HOST	COUNTRIES ATTENDING	RESULTS
1	Brussels, Belgium (Refer to Volume 2, Appendix F)	4/10-11/75	NATO HQ.	Belgium, Canada, FRG, France, Italy Netherlands, U.S.	Organizational meeting: A draft of the glossary was reviewed; several tasks were defined: project reporting form Intern'l Proj. Catalog & methodology for measuring & reporting performance.
2	Apeldoorn, Netherlands (Refer to Volume 2, Appendix G)	12/9-10/75	TNO	Belgium,FRG, France, Italy, Netherlands, Sweden, U.K., U.S.	Reviewed and approved Glossary. Data Format & Measurement Tech. Comm. were formed & their tasks defined. Project Summary Form reviewed for first time.
3	Moret-sur-Loing, France (Refer to Volume 2, Appendix H)	5/18-19/76	EDF	Austria, Belgium FRG, France, Italy, Netherlands, Sweden, U.S.	Distributed Glossary; the two working subcommittees met; reviewed Project Summary Form; discussed Project Progress/ Evaluation Report and Catalog format; discussed first draft of methodology for measuring and reporting performance; established Research Needs Committee.

TABLE 1
(Continued)

MTG #	LOCATION	DATE	HOST	COUNTRIES ATTENDING	RESULTS
4	Juelich, Federal Republic of Germany (Refer to Volume 2, Appendix I)	12/7-9/76	KFA	Belgium, FRG, France, Italy, Netherlands New Zealand, Spain, Sweden, U.S.	The working subcommittees met, the first draft of the International Project Catalog submitted, Project Summary Form & format of Catalog approved, revised & discussed draft of the standard methodology prepared by the Measurement Technology Committee. Assignments made for preparing particular chapters of the standard methodology for approval at the next meeting. Ad hoc committee formed to make recommendations on future activities to CCMS Plenary. Group appointed to prepare report on "Incentives and Barriers" to MIUS implementation.

TABLE 1
(CONTINUED)

MTG #	LOCATION	DATE	HOST	COUNTRIES ATTENDING	RESULTS
5	Turin, Italy (Refer to Vol. 2, Appendix J)	7/12-14/77	CNR/FIAT	Belgium, France, FRG Italy, Netherlands, U.K. and U.S.	The working subcommittees met & submitted their reports & recommendations to the overall committee; the final draft & addendum of the Intern'l Proj. Catalog were approved for submittal to the Fall Plenary Session, October 18-19, 1977; an outline of the final report to the Fall Plenary Session was approved; the standard methodology for reporting the performance of MIUS type of systems recommended research needs & recommended future activities were approved for inclusion in the final report to the Fall Plenary Session. The paper on "Incentives and Barriers" was reviewed and discussed. The Incentives and Barriers committee was directed to prepare a revised draft, circulate it to those in attendance for approval and subsequent submissions to a future Plenary Session in a follow-up report.

The fifth and final meeting of the CCMS-MIUS Project was held at the FIAT Central Research Laboratory, Orbassano, Italy (near Turin), July 12-14, 1977 during which reports were approved, activities concluded and recommendations for submittal to the Fall CCMS Plenary, October 18-19, 1977 approved.

2.0 CCMS-MIUS PROJECT

2.1 Origin and Objectives

The CCMS-MIUS Project is one among several projects that comprise the Rational Use of Energy Pilot Study. The project was organized as a result of strong international interest in improving methods for providing improved utility services to communities. The MIUS concept of integrating the services into a single plant is the major thrust and distinguishing characteristics of the project.

The objectives of the CCMS-MIUS Project were to identify MIUS Type of Projects in participating countries and to develop a mechanism for transferring technical data resulting from these projects to experts in the participating countries.

In particular, the CCMS-MIUS Project sought 1) to develop and maintain a continuing mechanism for the exchange of operating and design data on total energy systems, integrated utility systems, district heating, incineration of solid waste with heat recovery, and large scale application of solar thermal systems and energy storage, and fuel cells and other advanced power conversion applicable for use in total energy and integrated utility systems, i.e. non-central station application and 2) to develop standardized methodologies of measurement, analysis and reporting on and comparing of technological and economic efficiencies of the existing demonstration facilities and demonstrations to be constructed.

2.2 Participating Countries

Forty-three experts from twelve countries participated in the project's 2-1/2 year life span. They came from Austria, Belgium, Canada, Federal Republic of Germany, France, Italy, Netherlands, New Zealand, Spain, Sweden, United Kingdom and the United States.

Two additional countries, Japan and Denmark, submitted Project Summary Forms for the International Project Catalog, but did not attend the meetings. A Project Summary Form for a project in Finland was submitted by the Netherlands.

2.3 Description of the MIUS Concept

The Modular Integrated Utility System concept brings together subsystems that together provide improved means for furnishing essential services for residential communities.

The MIUS "recycles energy" by providing an option to package into one processing plant all of the six utility services necessary for community development.

- electricity
- space heating and water heating
- air conditioning
- solid waste processing
- wastewater treatment
- residential water purification

Conventional methods of generating electricity convert about 35% of the energy input to electrical output. The remaining 65% is vented to the atmosphere or flowing water in a manner that optimizes the electrical conversion process. MIUS theoretically can recover better than half of this rejected energy and use it for space heating, air conditioning, water heating, and to improve wastewater treatment efficiency. An additional 5-10% fuel savings can be made by recycling solid waste for its energy content.

In addition to saving energy, MIUS minimizes the environmental impact of utility systems.

The overall objectives of the MIUS concept are to:

- Provide utility services in an improved manner with decreased environmental impact and increased efficiency in the utilization of natural resources;
- Provide utility service capacity at a pace equal to the rate of growth of the new development;
- Make land available for development in areas that are not being serviced by conventional utility.

2.4 Definition of "MIUS Type of Project"

The following criteria was used to select projects for the catalog.

Although the MIUS concept connotes the integration of up to six utility services, a MIUS for CCMS purposes and for the Catalog will be thought of as having six utility services. A "MIUS Type of Project" can be any of a broad range of utility/energy systems which include a MIUS and are related to, or part of, a MIUS. Thus, a "MIUS Type of Project" is broader than the concept definition of a MIUS.

"Integrated" refers to use of a combined plant to furnish more than one utility service with a total system approach, whereby some resource requirements of one utility would be met by the effluent of another.

For the purpose of the International Project Catalog, a "MIUS Type of Project" is one that involves a utility system/subsystem that is, or has the potential to be, integrated with one or more utility system(s)/ subsystem(s) to produce those utility services more efficiently and economically than would be possible with independent (non-integrated) systems.

Project

What constitutes a project? A project acceptable for inclusion in the International Project Catalog should be hardware oriented. A project may even be a study, such as a feasibility study, if it has major national significance, or if it could lead to the construction of an actual system or shows that an application is not feasible.

An acceptable hardware system may be a research-oriented laboratory or pilot plant investigation, or it may be a demonstration or commercial facility which is serving actual community utility loads. A laboratory investigation would most likely be one for equipment or subsystem development, a pilot plant would be one for experimentation with future plants or system development in mind, a demonstration facility would be one constructed specifically to prove feasibility of an actual real-life plant by acquisition and evaluation of data. A commercial facility serving an actual community or industry is highly desirable as a CCMS-MIUS project if basic operating data is available for evaluating performance.

Modular

What is meant by Modular? Modular can have several meanings when applied to an integrated utility system. Some ideas that were helpful in determining a "MIUS Type of Project" for the CCMS-MIUS Project are as follows:

1. Modular may connote a small community size plant serving a small community or part of a community. Thus, the modular system is part of the overall infrastructure. It could be a small facility serving a shopping center, a school, a hospital, an apartment complex or a combination of these.

2. Modular may connote a small community size plant with the potential to grow in increments as the community grows. Thus the added increment could be considered a module.

3. Modular may represent the structure of the integrated utility system itself, since an integrated utility system would consist of subsystems. Thus a subsystem could be considered a module.

MIUS Type of Projects

The following definitions and guidelines of "MIUS Type of Projects" were used in considering projects for the catalog.

1. MIUS - An integrated utility system where all utility subsystems are integrated to provide utility services better, more economically and with less fuel consumption than conventional systems. A MIUS provides power, space heating/cooling, domestic hot water, solid waste processing, wastewater treatment and provisions for potable water. A MIUS recovers rejected heat from power generation and refuse incineration, and reduces undesirable discharges to the environment. It is recognized that a MIUS, no matter how well designed and operated, cannot achieve maximum overall efficiency all of the time. All rejected heat that is reclaimable is unlikely to be needed 100 percent of the time, e.g. very little, if any, space heating/cooling may be needed during mild temperatures.

2. Total Energy System - An integrated utility system that provides power, space heating/cooling and domestic hot water. It recovers rejected heat from power generation.

3. Integrated Utility System (other than a complete MIUS or Total Energy) - Two or more utility subsystems which are integrated. Examples are: use of renovated wastewater for use in power plant cooling towers, solid waste processing with incineration and wastewater treatment, and wastewater treatment with water renovation or reuse. A MIUS and a Total Energy System are special cases of an Integrated Utility System.

4. District Heating - A system by which heat is supplied to buildings in an urban area through insulated pipelines from one or more heat sources situated external to the buildings. Any district heating system that has the potential or is to be integrated with another utility subsystem (refuse incineration or power generation, to provide better services at less cost) should be included.

5. Utility System - A system that furnishes a single utility service. A utility subsystem that is being improved or developed for integration with another utility system or one that is being improved to enhance the integration process should be considered. This would include, for example an improved method of recovering heat during power generation.

6. Component/Equipment - A component or piece of equipment that is being improved or developed specifically for the purpose of improving the integrated utility system/subsystem, or the integration process. For example: Thermal Storage Systems, boilers, heat pumps, heat exchangers, etc. Note: A project to improve a component or piece of equipment such as a boiler or heat pump, with no specific objective related to integrated systems should not be considered a project for the CCMS-MIUS International Project Catalog.

Scale

Although modular in "MIUS" has sometimes been interpreted as being limited to small scale plants, this is not correct. For the purpose of identifying projects all size plants which followed the type of projects listed above were considered.

Status

Projects in the planning stage, on-going, or completed were accepted for inclusion in the International Project Catalog. A project was not considered complete until the final report had been published or released and data evaluated.

Availability of Data

A pilot plant, demonstration facility or commercial system should be one in which good quality data that will be useful in analyzing plant performance is being acquired and is readily accessible. The more data available the better, however, operational data such as that produced by a commercial system was adequate in choosing candidates for the project catalog.

2.5 Subcommittees of the CCMS-MIUS Project

The CCMS-MIUS Project Committee appointed five working subcommittees to carry out the tasks that it identified and undertook in carrying out the objectives of the project. They are the Data Format Committee, the Measurement Technology Committee, the Research Needs Committee, the Ad Hoc Committee on Future Activities and the "Incentives and Barriers" Committee.

The Data Format Committee was assigned responsibility for preparing and developing a glossary of special terms unique to MIUS, a reporting form for compiling project descriptions of MIUS Type of Projects, the International Project Catalog for compiling project descriptions of MIUS Type of Projects, and the Project Progress/Evaluation Report form to identify the type of information required for reporting performance and for evaluating and comparing MIUS Type of Projects.

The Measurement Technology Committee was asked to prepare and develop a standard methodology for measuring the performance of MIUS Type of Projects and the reporting and taking of data.

The Research Needs Committee was asked to identify research needs in the development and furtherance of integrated utility system technology to improve its technical, environmental, economical and institutional viability.

The Ad Hoc Committee on future activities formulated recommendations for future activities to carry on the work of the CCMS-MIUS Project after the project's termination.

The "Incentives and Barriers" Committee was asked to prepare a paper on the incentives and barriers to the implementation of integrated utility systems such as co-generation, total energy, MIUS, district heating utilizing waste heat recovery, solid waste incineration with waste heat recovery and wastewater processing with renovation and reuse.

The countries assigned to the working subcommittees and their representatives who served are as follows:

a. Data Format Committee
   Canada (K.R.Solvason)
   Italy (M. Mangialajo)
   Netherlands (J.W.H.Van den Bergh)
   United Kingdom (P.J.O'Neill)
   United States (C.W.Phillips)-Chairman

b. Measurement Technology Committee
   France (T.Grjebine)
   Federal Republic of Germany (H.Klein/F.Richter)
   Netherlands (J.A.Knobbout) - Chairman
   Sweden (U.Renghold)
   United States (C.W.Phillips)

c. Research Needs Committee
   Belgium (J.A.Michel)-Chairman
   Federal Republic of Germany (H.Klein/W.Pillar)
   United States (S.Cavros)

d. Ad Hoc Committe
   Belgium (J.A.Michel)
   Federal Republic of Germany (U.Plantikow)
   Netherlands (J.A.Knobbout)
   United States (Patrick Folan - U.S. NATO CCMS Officer
   (C.W.Phillips - Chairman)
   (J.H.Rothenberg, Head U.S.delegation)

e. "Incentives and Barriers" Committee
France (T.Grjebine) - Co-Chairman
Italy (M.Mangialajo)
United States (S.Cavros) - Co-Chairman

3.0 ACTIVITIES AND PRODUCTS OF THE CCMS-MIUS PROJECT

3.1 Glossary of Special Terms

The Glossary of Special Terms unique to MIUS type of projects (Refer to Appendix A) was developed in order to expedite and promote a greater understanding among the experts in the transfer of information on MIUS type of projects. Terms that are well known and accepted and are not likely to be misunderstood or misinterpreted when applied to MIUS type of projects were not included.

3.2 Project Summary Form

A two page reporting form (Project Summary Form, refer to Appendix B) was developed by the CCMS-MIUS Project Committee at its first meeting to provide project descriptions of MIUS type of projects and to become an integral part of the International Project Catalog (Refer to paragraph 3.3). Subsequently, the U.S. delegation prepared a standard form requesting data on the performing organization, the supporting organization, theprincipal investigator, duration of the investigation, funding, purpose of the project, status and results, the utility services provided, type of project (public, private, cooperative) a means to identify whether data would be available for exchange, technical data and a list of related projects.

3.3 International Project Catalog

The International Project Catalog* was identified at the first meeting as a means to provide a collection of project descriptions (Project Summary Forms) of MIUS Type of Projects. The responsibility for compiling the catalog was assigned to the Data Format Committee.

The International Project Catalog was designed as the first of a three level reporting system (Phase I) to report data on MIUS Type of Projects. The catalog is comprised of Project Summary Forms. This first phase was designed to be all inclusive without identifying successful or marginally beneficial projects, but to make certain that all appropriate projects were covered. The information contained on Project Summary Forms is a broad overview of what the system is supposed to accomplish rather than a detailed analysis. The Project Summary Form in general, indicates

*The International Project Catalog, NATO/CCMS-73 will be published as a separate document.

where a project is located, who is responsible for its development and what results generally is to be expected. Enough information is available to allow a quick assessment of a project's merits and whether more information would be desirable. If in fact more information is necessary in order to determine whether this system would serve a given set of needs as perceived by the decision maker, then he would request a Project Progress/Evaluation Report, refer to paragraph 3.4.

3.4 Project Progress/Evaluation Report

The Project Progress/Evaluation Report provides a uniform method for reporting progress and evaluation of MIUS Type of Projects. Appendix C contains the Project Progress/Evaluation Report form. The responsibility for developing the report form was assigned to the Data Format Committee.

The report form was designed as the second level of the three level reporting system (Phase II). It is intended as an executive summary of MIUS Type of Projects and to provide technical data and information useful in the evaluation process. Obviously not all systems reported in Phase I are appropriate for the systems, Phase II reporting.

The purpose of Phase II reporting is to provide an expert with more information than is included in the Project Summary Form. He may contact the principal investigator or sponsoring organization to obtain the Project Progress/Evaluation Report if one is available. The report may not necessarily follow the same outline provided in the report form, but generally it will provide the information requested as appropriate for that particular project. The availability or future availability of a Project Progress/Evaluation Report may be indicated by whether the "Exchange of Data" box (12) on the Project Summary Form has been checked "yes or no".

From the Project Progress/Evaluation Report, an expert can make valid comparisons among similar projects to determine which one is best suited for a given set of conditions. The format is also such that problems and their solutions can be assessed and comparisons made. Frequently, similar projects in different locations have varying degrees of success, and it becomes quite difficult to determine what the critical factors are. Phase II should eliminate this variance or at least reduce its magnitude.

The completion of the Project Progress/Evaluation Report form is identified as one of the future tasks in the recommendations for the continuation of the CCMS-MIUS Project activities.

3.5 Standard Methodology for Measuring the Performance of MIUS Type of Projects

The standard methodology for measuring the performance of MIUS Type of Projects and for the reporting and taking of data was identified at the first meeting and was assigned to the Measurement Technology Committee under the leadership of Mr. J.A. Knobbout of the Netherlands for development.

The standard methodology is the third level of the three level reporting system (Phase III). It provides a standard methodology useful to administrators, engineers, economists, investors, regulatory authorities and potential users in measuring and appraising the performance of a MIUS Type of Project. It provides guidelines for acquiring data that will be comprehensive and applicable to all MIUS Type of Projects. It identifies the parameters that should be measured and the engineering variables that should be derived. The standard methodology also provides a format for reporting the data. The standard methodology is applicable to an operating system, a demonstration facility, a pilot or prototype facility and a laboratory model. It can be used as the basis of the final report of a project. It could contain data compiled over the entire testing period or over a specific data period.

The participants suggested that the standard methodology task should be continued. Appendix D represents a significant beginning in the development of the standard methodology for measuring the performance of a MIUS Type of Project.

3.6 Research Needs

The Research Needs Committee was formed at the third meeting to identify the need for future research in integrated utility systems, and to prepare a list of priorities describing these needs for inclusion in this report.

At the fourth and fifth meetings of the CCMS-MIUS Project Committee, Mr. Michel, Chairman of the Research Needs Committee presented a general framework for combined production of heat and electricity. Five categories of needs were identified. They are (1) fundamental research; (2) technological research; (3) research and development of component and system research; (4) economics and (5) institutional and organizational.

The research needs given the highest priority are:

1. FUNDAMENTAL RESEARCH

    a. Stimulate research in new levels of new systems power conversion at all intervals (i.e. temperature levels) applicable to the available thermodynamic range. (For example: Multiple levels of power conversion).

    b. Reduce second law losses by controlling combustion through innovative design (i.e. maximize use of heat content in fuel).

c. Improve and develop new materials for piping systems: particularly to reduce corrosion and increase durability.

d. **Improve** Metering Technology: hot chilled water and steam.

e. Energy recovery from solid waste:

° Develop methods for the measurement, characterization and control of effluent stream pollutants.

° Develop methods for sampling, analysis and classification procedures for waste fuels.

° Examine and elucidate the mechanisms of corrosion of materials of contruction of fuel fired systems.

° Develop a uniform and equitable energy and resource recovery system economic analysis procedure.

° Develop materials handling processing and separating systems specific to waste fuel utilization.

° Establish a mechanism for the acquisition and dissemination of technology relating to waste to energy systems.

2. TECHNOLOGICAL RESEARCH

a. Improve and develop coal utilization by small systems.

b. Improve diesel engine exhaust heat recovery techniques and exhaust and stack heat exchangers. Also include heat recovery from boilers and other available sources.

c. Study and Improve methods and design for retrofitting existing turbines to combined heat and power.

d. Improve turbines that can adapt to both power and heat production with high energy efficiency.

e. Develop large scale thermal storage techniques.

f. Improve thermal distribution systems.

g. Also see 1-b.

h. Improve Technology transfer.

i. Improve treatment and disposal of Industrial and Municipal wastes by studying, performing or preparing:

°Physical properties of prepared refuse.

- State-of-the-act survey of waste storage and feeding mechanisms, non-thermal waste processes, thermal waste processes (direct combustion and indirect combustion), non-thermal sludge processes, combined sludge wastes thermal and non-thermal processes control technology for thermal processes.
- Characterization of hazardous and toxic wastes.
- A primer on combustion systems.
- Chemical and physical kinetics in waste combustion.
- A steam generator as a calorimeter.
- Energy recovery and emissions potential as a function of fuel homogeneity
- Characterization of HCL emissions.
- Qualify and quantify ash in thermal processes.
- Delete correction to 12% CO_2
- New product design from waste disposal viewpoint.

3. RESEARCH AND DEVELOPMENT OF COMPONENT AND SYSTEM RESEARCH

   a. Improve and develop heat mapping and system planning techniques.

   b. Improve and develop combined power and heating station planning and operational analysis.

   c. Investigate technology assessment, particularly of District Heating (the technical environmental, societal and institutional impact of District Heating).

   d. Achieve full utilization of state-of-the-act in designing plants, instrumentation, components, energy transfer techniques.

   e. Also see 2-i.

4. ECONOMICS

   a. Minimize piping and trenching costs.

   b. Perform study of comparative Life-Cycle cost of District Heating and Alternatives.

5. INSTITUTIONAL AND ORGANIZATIONAL

   Determine the need for and legal and institutional feasibility of legal requirements forcing connection to District Heating Systems.

3.7 "Incentives and Barriers" Paper

The "Incentives and Barriers" committee was asked to develop a paper on the "Incentives and Barriers" to the construction of MIUS Type of Projects.

Participants decided that since the institutional factors differ in the participating countries, the paper should include inputs from the various participating countries. A revised paper should be included in a follow-up report.

4.0 SUMMARY OF ACCOMPLISHMENTS

The following products were prepared by the CCMS-MIUS Project Committee:

1. A Glossary of Special Terms Unique to MIUS Type of Projects. (Appendix A).

2. The International Project Catalog, a compilation of 209 project descriptions of MIUS Type of Projects. (NATO/CCMS Publication 73).

3. A Project Progress/Evaluation Report form. (Appendix C).

4. A standard methodology for measuring the performance of MIUS Type of Projects and for the collecting and reporting of data was prepared. Refer to (Appendix D).

5. A list of research needs in integrated utility systems. (Appendix E).

6. Initial work on a paper on the "Incentives and Barriers" to the implementation of MIUS Type of Projects.

APPENDIX A

GLOSSARY OF SPECIAL TERMS
FOR THE
COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY - MODULAR INTEGRATED UTILITY SYSTEMS (CCMS-MIUS) PROJECT
OF THE
RATIONAL USE OF ENERGY PILOT STUDY

(Prepared by the Data Format Committee)

MAY 18,1976

This glossary has been prepared to include special terms that are unique to Modular Integrated Utility System (MIUS) and Total Energy (TE) technology processes. Terms that are well known and accepted and are not likely to be misunderstood or misinterpreted when applied to MIUS and TE, are not included. The glossary includes terms used in power generation, heating and cooling systems, waste heat recovery, solid and liquid waste processing, potable water and their integration.

Should you have any additions or changes you would like to recommend, please forward them to C.W.Phillips, National Bureau of Standards, Building 225, Room A146, Washington, D. C. 20234, U.S.A.

1. absorption refrigeration - that type of refrigeration cycle which uses heat rather than mechanical energy for the refrigerant fluid's compression process.

2. article of commerce (commercial article) - a manufactured system, subsystem or component which (1) is commercially available (2) is listed in commercial catalogues showing overall physical and performance characteristics and ratings (3) has been in commercial use (4) can be covered by a warranty or performance bond.

3. baseline - a reference set of functional standards or performance criteria of an initial and firm description in terms of hardware components of a system/subsystem from which all future design changes in that system/subsystem are made.

4. baseload - (1) the minimum load over a given period of time (2) that portion of the load profile over a specified period of time which determines minimum continuous capacity of a subsystem.

5. capacity - the maximum load for which a system, subsystem or component is rated.

6. capacity factor - the ratio of the average load on a subsystem or component to the installed capacity rating of the subsystem, or component.

7. capital charges - (also referred to as owning costs). Charges in the account of a person or organization for depreciation (recapture of principal, capital cost, or repayment of loans.)

8. capital cost - the aggregate cost of an installed system, i.e. engineering and design costs, land costs, building, equipment, materials, installation and construction costs.

9. cash flow - the flow of money payments to or from a producer. Expenditure is sometimes referred to as a "negative" cash flow. The gross cash flow of a producer is the gross profit (after payment of fixed interest) plus depreciation provisions in any trading period, i.e. that sum of money which is available for investment dividends or payment of taxes. The net cash flow is retained earnings and depreciation provisions before or after taxes. Net cash flow of a particular project are usually defined as those arising after taxes have been paid, expenditure on repairs and maintenance carried out, any necessary adjustments made to working capital and account is taken of any residual value of assets at the end of a particular project's life or other miscellaneous income accruing to the project.

10. chilled water cooling system - (refer to cooling system, chilled water).

11. coefficient of performance - (1) the ratio of the rate of heat output to the rate of energy input, in consistent units for a complete refrigerating or heat pump facility or some specific portion of these facilities, under designated operating conditions. (2) the ratio of thermal energy delivered by the system to the energy input into the system in dimensionless units.

12. coincident demand - (1) any demand that occurs simultaneously with any other demand for a single utility service (2) also the sum of any set of individual coincident demands for a single utility service (Syn: aggregated coincident demand).

13. combined cycle - refers to that type of thermal energy plant cycle which utilizes the high temperature exhaust heat from a prime mover to produce steam, in a waste heat boiler, for a steam turbine cycle.

14. commentary - a part of a performance specification which is not legally binding but which clarifies, amplifies or illustrates a performance criterion. (Also refer to criterion, evaluation, performance specification and requirement).

15. common trenching - the practice of burying utility distribution and collection lines together in excavated ground or a single trench to be distinguished from placement in utility tunnels.

16. component - a hardware element or unit process of a MIUS subsystem.

17. connected load - the sum of the continuous utility ratings of all utility consuming apparatus connected to a utility service subsystem.

18. control system - (1) a system by which a desired effect is achieved by operating on the input (or inputs) to the system until the output, which is a measure of the desired effect, falls within a predetermined range of values, (2) a system which measures demand for a utility service and adjusts the subsystem to supply this service.

19. cooling system, chilled water - a water cooling system operating with a usual design supply water temperature of 40-55 degrees Fahrenheit (4.4-12.8 Celsius) and within a pressure range of 125 pounds per square inch (.862 Meganewtons per square meter).

20. cost - the value of the factors of production used in producing or distributing goods and services or engaging in both activities. Important cost elements:

a) direct cost - the ordinary expenditures to purchase goods or services or the value of goods and services purchased for production.

b) opportunity cost - (1) value of goods and services owned by the producer and used in production or (2) nonexpenditures which accrue directly to the producer itself. These costs arise when factors (such as production factors) and money capital are owned by the producer.

c) external cost - (spillover cost) costs that should ordinarily be involved in production but are borne by those not benefitting, e.g. stream pollution caused by discharges from a factory that the downstream user must remove before use.

d) societal cost - the sum of the above costs.

21. cost-benefit analysis - a technique used to evaluate the social costs and social benefits of investment projects to find the best alternative or to decide whether or not the project(s) should be undertaken. The essential difference between cost-benefit analysis and ordinary investment appraisal methods used by firms is the stress on the social costs and benefits.

22. criterion - a part of a performance specification which is the measures and levels (preferably stated in quantitative terms) used to establish that a certain requirement is met, e.g. a standard of judgment, a benchmark. (Also refer to commentary, evaluation, performance specification, requirement.)

23. demand (commonly referred to as average demand) - (1) the rate at which a utility service is delivered to users or groups of users (load) averaged during a specified, continuous demand interval. Demand may also be considered as occurring at a given instant, (2) the rate at which a user or group of users require a utility service to provide a specified environment.

24. demand, diversified - the maximum aggregated coincident demand (sum of the simultaneous demands) of users or groups of users. This is less than the sum of the individual maximum demands. The diversity results from the fact that the maximum demands of all the individual users or groups of users do not occur at the same time. The diversity factor.

25. demand factor - the ratio of the maximum demand to the total connected load.

26. demand, instantaneous - the demand at any moment, usually determined from the readings of indicating or recording instruments.

27. demand, interval - the period of time upon which the demand measurement is based. (Generally less than an hour.)

28. demand, maximum - the greatest demand imposed upon a utility system by users or groups of users at the same demand interval within a specified period.

29. depreciation - a reduction in the value of fixed assets due to the loss in value of buildings and components because of wear and tear, age, or technical obsolescence. The annual amount of depreciation of an asset depends on its original purchase price, its estimated useful life and its estimated salvage value.

30. disposal - the final disposition of wastes either on or in the land, or the conversion of wastes into some other product.

31. distribution system efficiency - the ratio of total product delivered by a distribution system to the total product input to the distribution system.

32. diversified demand - the maximum aggregated coincident demand (sum of the simultaneous demands) of users or groups of users. This is less than the sum of the individual maximum demands. The diversity results from the fact that the maximum demands of all the individual users or groups of users do not occur at the same time. The diversity is quantitatively expressed by a diversity factor.

33. diversity factor - the ratio of the maximum aggregated coincident demand (sum of the simultaneous demands) of users or groups of users to the sum of their individual maximum demands.

34. double effect (two-stage) absorption chiller - this machine incorporates a (two-stage) multiple effect concentrator into the lithium bromide/water absorption cycle, which provides substantially better efficiency than the earlier single-stage machine. With the two-stage machine, energy consumption is reduced by about 30 percent at full load, and up to 35 percent on an average or annual basis.

35. dual temperature water heating/cooling system - (refer to heating/cooling system, dual temperature water.)

36. efficiency - the ratio of the effective or useful output to the corresponding total input to a system, subsystem or component especially the ratio of the utility service delivered by a subsystem to the subsystem's input.

37. energy analysis - the procedure of mathematically modeling the MIUS energy conversion processes and end use load requirements in order to simulate and predict energy consumption.

38. energy balance - calculations which account for the disposition of all energy put into a system, subsystem, or component, its effective energy output, energy returned to the system, subsystem or component, and energy rejected as unavailable or useless to the system, subsystem or components.

39. energy efficiency - the ratio of the total energy output in the form of useable utility services from a system or subsystem to the total energy input.

40. energy loss - that part of the energy input to a conversion, transmission, or distribution process or system, subsystem, or component which does not perform useful work in the production a utility service.

41. energy recovery - recovery of energy from an energy resource such as solid waste. (For example - the burning of solid waste to produce heat for space and process heating, air conditioning, and/or generation of electricity.)

42. evaluation - (1) a part of the MIUS performance specification which delineates the process of examining and judging the performance of a system, subsystem or component with a certain methodology and with a specified performance specification or set of criteria. (2) the process of examining and judging the performance of a system, subsystem or component with a specified performance specification, or examining and judging two or more alternatives and assigning a relative value or weight to various criteria in order to determine the best alternative. (Also refer to commentary, criterion, requirement, and performance specifications.)

43. factor, capacity - the ratio of the average load on a subsystem or component to the installed capacity rating of the subsystem, or component.

44. **factor, demand** - the ratio of the maximum demand to the total connected load.

45. **factor, diversity** - the ratio of the maximum aggregated coincident demand (sum of the simultaneous demands) of users or groups of users to the sum of their individual maximum demands.

46. **factor, load** - the ratio of the average load during a designated period of time to the peak load occurring in the same period.

47. **factor, plant** - (same as capacity factor).

48. **heat balance** - (1) the amount of heat needed for space heating and air-conditioning and other MIUS processes relative to the amount available as a recovered by-product from MIUS energy conversion processes (2) calculations which account for the disposition of all thermal energy input to a system, subsystem, or component including outputs, recovered heat and lost heat.

49. **heating/cooling system,dual temperature water** - a combination hot water heating and chilled water cooling system which circulates hot or chilled water, or both, to provide heating or cooling. Dual temperature systems are operated within the temperature limits of low temperature water systems, with usual winter design supply water temperatures of about 150-200 degrees Fahrenheit (65.6 - 93.3 degrees Celsius) and summer supply water temperatures of 40-55 degrees Fahrenheit (4.4-12.8 degrees Celsius).

50. **heating system, hot water** - a heating system in which hot water is used as a medium to convey heat from a central boiler, through a piping system to suitable heat distributing means. A high temperature water heating system has supply temperatures above 350 degrees Fahrenheit (176.7 degrees Celsius) a medium temperature water heating system between 250 degrees Fahrenheit (121.1 degrees Celsius) and 350 degrees Fahrenheit (176.7 degrees Celsius) and a low temperature water heating system (commonly called a hot water heating system) less than 250 degrees Fahrenheit (121.1 degrees Celsius).

51. **heating system, steam** - a heating system in which steam is used as a medium to convey heat from a central boiler through a piping system to suitable steam distributing means. A high pressure steam heating system employs steam at pressures above 15 pounds per square inch gage (.103 meganewtons per square meter gage), a low pressure steam heating system, between 0 and 15 pounds per square inch gage (0 and .103 meganewtons per square meter gage).

52. **hot water heating system** - (refer to heating system, hot water).

53. **hydronics** - the technology of heating and cooling with liquids.

54. **infrastructure** - (refer to utility infrastructure).

55. **instantaneous demand** - (refer to demand, instantaneous).

56. **institutional factors** - a wide variety of nontechnical forces, both positive and negative, affecting MIUS and existing as a result of the socio-political environment in which MIUS must exist.

For example, tax incentive legislation; construction subsidiaries; zoning regulations.

57. integration - that property or act of linking together all MIUS subsystems, thereby creating the overall MIUS system which is more efficient than the sum of the individual subsystems.

58. interface requirements - constraints imposed on a subsystem or component in order to affect system integration.

59. life cycle cost - the total cost (acquisition, fuel, repair, replacement and labor costs) or acquiring, owning, operating and maintaining a system, subsystem or component over its useful life span.

60. live model - a model of any part of the overall utility system which is based upon a specific existing installation. For example, an existing housing development which may be used as a consumer model with hypothetical, typical or average type utility subsystem models for analytical studies.

61. load - (1) the rate of delivery of utility service to or imposed by users or groups of users (2) the output of a MIUS subsystem which is equal to a utility demand from users or groups of users.

62. load factor - the ratio of the average load during a designated period of time to the peak load occurring in the same period.

63. load leveling - the achievement of a more constant production rate for a service which experiences a cyclic demand by means of adding energy storage or by load shedding under non-emergency conditions.

64. load, peak - the maximum load consumed or produced in a stated period of time.

65. load profile - a curve showing the demand of a utility service, plotted against time of occurrence and illustrating the varying magnitude of the load during the period covered.

66. load shedding - a systematic and orderly method of decreasing the load on a utility service plant to match plant capacity with demand in emergency situations. The load reduction is usually achieved by temprorarily discontinuing service to certain users.

67. lost heat - all heat generated by MIUS which is not recovered and beneficially used.

68. maximum demand - (refer to demand, maximum).

69. MIS - (Monitoring Instrumentation System) - (1) an instrumentation system necessary to obtain sufficient data to verify compliance of the MIUS with the MIUS program objectives including the MIUS performance specifications (2) an instrumentation system which gathers data on the conditions of the physical process being measured.

70. MIST (MIUS Integration and Subsystems Test) - a hardware system that serves as the test bed for evaluation of subsystems design concepts for the MIUS program.

71. MIUS - (Modular Integrated Utility System) a limited-size utility system (limited to community scale) which provides some or all utility services (electric power, heating and cooling, domestic hot water, wastewater and solid waste processing, and potable water) to a community in a single processing plant. The essential element of a MIUS is the integration of service systems to achieve resource conservation, and environmental and cost benefits. Integration may take such form as the recovery of waste heat from electric power generation and heat from solid waste incineration to provide heating and cooling, domestic hot water and wastewater processing.

72. MIUS Plant Performance Acceptance Test - a test or series of tests performed under HUD direction to determine whether the performance of the MIUS Demonstration Plant satisfies the MIUS Site Specific Performance Specification. This test requires a minimum of one calendar year, after an acceptable level of occupancy (refer to occupancy, acceptable) has been achieved.

73. Modular Integrated Utility System - (refer to MIUS).

74. Monitoring Instrumentation System - (refer to MIS).

75. occupancy, acceptable - that level of occupancy that will permit initiation of the MIUS Plant Performance Acceptance Test as determined acceptable by the HUD GTR according to the following guidelines: (1) a demonstrated average daily consumption for each of the utility services provided by the MIUS Demonstration Plant of approximately 80 percent or more of the predicted average daily consumption of those utility services. In addition (2) continuation of the consumption level for a period of not less than two consecutive weeks.

76. overcost - (1) that incremental excess in cost between the actual cost of developing and constructing the MIUS demonstration community development and the proposed cost of developing and constructing an identical residential community (without MIUS using conventional utilities) (2) the marginal (additional) development and construction cost of a MIUS compared to a system using conventional methods.

77. owning costs - (Refer to capital charges)

78. payout - a rough measure of economic performance; (1) the ratio expressed in years of total (or incremental) investment cost in a project to total (or incremental) net annual operating savings, (2) the period over which the cumulative net revenue from an investment project equals the original investment.

79. peak load - (refer to load, peak).

80. performance specification - a schedule of statements that define the ranges, limits and constraints associated with the functions of a system and its subsystems and components. (Also refer to commentary, criterion, evaluation and requirements).

Example: One single state centrifugal pump to pump 300 gallons per minute (1135.624 liters per minute) of water at a temperature of 390 degrees Fahrenheit (198.9 degrees Celsius) against a total dynamic head of 120 feet (36.576 meters). Specific gravity of water at pumping temperature of .89. Available net positive suction heat of 15 feet (4.572 meters).

81. plant factor - (same as capacity factors).

82. point design - a specific design for a particular application.

83. prescriptive specification - (as opposed to merely a performance specification) (1) a detailed listing of basic requirements for a component, its capacity, rating, materials of construction, quantitative engineering and design data and codes to be met. (2) A specification which not only defines how a price of equipment will perform (performance specification) but also defines how this performance will be achieved and how the equipment will be constructed.
Example: One single stage 2 x 3-13 centrifugal pump to pump 300 gallons per minute (1135.624 liters per minute) of water at a temperature of 390 degrees Fahrenheit (198.9 degrees Celsius) against a total dynamic head of 120 feet (36.576 meters). Specific gravity of water at pumping temperature.89. Available net positive suction head 15 feet (4.572 meters).

pump construction - Case: Cast Ductile Iron, Heat Treated - ASTM A395
Impeller: Cast Iron ASTM A278 Class 25
Shaft: Wrought Steel SAE 4140 ASTM A322 Grade 4140
Shaft Sleeves: 316 Stainless Steel ASTM A276
Coupling: Flexible, Falk or approved equal
Coupling Guard: "OSHA", Steel
Bedplate: Cast Iron with rim, ASTM A278

Water cooled bearing frame, restricting bushing in bottom of box, 300 pounds (136.078 kilograms) raised suction and discharge flanges, jacketed stuffing box, John Crane type 9 mechanical seal.
Pump Efficiency: 60 percent
B.H.P. at rating: 13.5
Max. B.H.P.: 14.8
Impeller Diameter: 11-3/4 inches (.298 meters)
Pump Driver: 15HP, 1800 RPM, open, drip proof, electric motor, 3 phase, 60 Hertz, 230/460 volts, Frame No. 254T
Manufacturer to furnish certified pump characteristic curve, 6 copies of certified dimensional drawings and perform witnessed pump performance test.

84. primary wastewater treatment - the first stage in wastewater treatment in which substantially all floating or settleable solids are mechanically removed by screening and sedimentation but little or no colloidal and dissolved matter.

85. process heat - thermal energy which is produced for and utilized in various industrial operations.

86. recoverable heat - that amount of waste heat which can practically be recovered for utilization.

87. recovered heat - (1) that amount of recoverable heat which is actually recovered for utilization or (2) that amount of heat normally lost to the atmosphere, but reclaimed by means of heat exchange equipment and utilized for beneficial use.

88. reliability - (1) a measure of the ability of the system, subsystem or component to deliver available continuous service to satisfy user demands (2) percentage of time a utility service is available to meet user demands.

89. requirement - a part of a performance specification which is a concise statement of what a system or element must be able to do: the unassailable principles to be achieved. (Also refer to commentary, criterion, evaluation, and performance specification.)

90. Secondary wastewater treatment - further processing of wastewater beyond the level of primary treatment. This term has also been given a legal definition by the United States Environmental Protection Agency. At present the quality level of the product stream is described in the following paragraphs.

(a) Biochemical oxygen demand (five-day).

(1) the arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 30 milligrams per liter.

(2) the arithmetic mean of the values for effluent samples collected in a period of seven consecutive days shall not exceed 45 milligrams per liter.

(3) the arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetic mean of the values for influent samples collected at approximately the same times during the same period (85 percent removal).

(b) Suspended solids.

(1) the arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 30 milligrams per liter.

(2) the arithmetic mean of the values for effluent samples collected in a period of seven consecutive days shall not exceed 45 milligrams per liter.

(3) the arithmetic mean of the values for effluent samples collected in a period of 30 consecutive days shall not exceed 15 percent of the arithmetic mean of the values for influent samples collected at approximately the same times during the same period (85 percent removal).

(c) Fecal Coliform Bacteria

(1) the geometric mean of the value for effluent samples collected in a period of 30 consecutive days shall not exceed 200 to 100 milliliters.

(2) the geometric mean of the values for effluent samples collected in a period of seven consecutive days shall not exceed 400 to 100 milliliters.

(d) pH. The effluent values for pH shall remain within the limits of 6.0 to 9.0.

91. selective energy system - a concept where part (generally 40-70 percent) of the required electrical power is generated on site by a generating system arranged for maximum use of input fuel energy by using the waste heat for space heating, space cooling and domestic water heating. The balance of the electrical power requirements is obtained from commercial sources.

92. sinking fund - the funds set aside on a periodic (usually annual) basis to accumulate over a stated (extended) period of time available for the ultimate repayment, partial or complete of a debt.

93. steam heating system - (refer to heating system steam).

94. solid waste - all unwanted or discarded solid materials and sewage sludge containing more than 20 percent solids by weight.

95. solid waste management - the purposeful and systematic control of the storage, collection, transport, separation, processing, recycling, recovery and disposal of solid wastes.

96. subsystem - (1) a group of components or a hardware system which provides a single utility service. Examples are solid waste subsystem, electrical power subsystem, (2) a group of components or a hardware system, not themselves providing a utility service, but providing a single function to a utility service system. Examples are control and monitoring subsystem and environmental control subsystem.

97. system - (1) the overall hardware array which provides complete utility services such as a MIUS. (2) combination of two or more utility subsystems.

98. technology assessment - a task effort within the MIUS program that estimates the total possible (primary, secondary and tertiary) impact on society of the implementation of MIUS as a new option in the provision of basic utility services.

99. technology evaluation - a task effort within the MIUS program that (1) conducts an information survey to establish the availability and status of subsystem and component technologies, (2) develops evaluation and selection criteria, and (3) selects the more promising technologies for further modeling and evaluation.

100. teritary wastewater treatment - any wastewater treatment operation beyond the secondary stage that increases the removal of contaminants. These operations can be used to remove nutrients, suspended solid or trace organics.

101. thermal balance - (1) the form of energy balance on which a "selective energy plant" operates. Electric power is generated to the degree necessary to provide recoverable heat to satisfy the thermal loads and without regard to the electrical demands. The electrical system is tied into a local grid and depending on the demands, excess power is fed into the grid or supplementary power is taken from the grid (2) calculations made for the purpose of analyzing the thermal properties of a subsystem or component.

102. thermal lag - the effect of heat storage of a structure and its contents which results in a maximum or minimum thermal load which is not coincident in time with corresponding maximum or minimum ambient temperature.

103. thermal efficiency - the ratio of useful work done by a heat engine to the heating value of the fuel supplied to the engines.

104. thermal load - the space heating and/or cooling, domestic hot water and process heating requirements to be met by the MIUS.

105. total energy (1) on-site power generation with waste heat designed reclamation (2) a concept of an on-site electrical power generating system arranged for maximum use of input fuel energy by using the waste heat for space heating, space cooling, and domestic water heating. Generally, a total energy system is completely independent of commercial power.

106. trade studies - studies to evaluate several options of a particular design.

107. utility infrastructure - various physical utility systems that provide utility service to a particular community area, e.g. water supply system, sewage system, power transmission system, etc.

108. waste heat - by product thermal energy produced as a result of some energy conversion or utilization process.

109. wastewater - the spent water of a community. It may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with any groundwater and surface water that may be collected and transported by the community. In recent years, the word wastewater has taken precedence over the word sewage.

110. wastewater management- the operations and plant involved in the collection, treatment and disposal of sanitary sewage and storm water.

111. wastewater treatment - (refer to primary wastewater treatment, secondary wastewater treatment, and tertiary wastewater treatment).

112. water reuse - the use of treated wastewater for some purposes before discharge.

APPENDIX B

PROJECT SUMMARY FORM
FOR THE
CCMS-MIUS PROJECT

September 20, 1976

(Prepared by the Data Format Committee)

NBS-1075
(2 77)

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Identification No.
(Secretariat Use Only)

PROJECT SUMMARY FORM

1 Title of Project *(Official Title)*

2. Date *(Form Completed)*

3. Performing Organization *(Complete Mailing Address)*

4 Principal Investigator *(Name and Complete Mailing Address)*

5 Supporting Organization *(Complete Mailing Address and Name of Contact)*

6. Duration of Investigation *(Beginning and ending)*

7 Estimated Funding and Manpower *(Monies and Manyears)*

8. Purpose of Project *(Objectives, Motivations, Approach, Plans and Expected Results)*

Use Box No 15 if additional space is needed

9. Status and Results

This project is ☐ planned ☐ in-progress ☐ completed

Use Box No. 16 if additional space is needed

10. Utility Services

☐ electrical power
☐ space heating
☐ space cooling
☐ potable hot water
☐ wastewater treatment
☐ solid waste processing
☐ potable water

11. Type of Project

☐ public ☐ private

☐ cooperative

12. Exchange of data

Will data be available from this project that will be shared with others? ☐ Yes ☐ No

13. Technical Data

Identification No

project location

degree-days (heating)

degree-days (cooling)

plant load capacity

a. power (MW)

b. heating (MW)

c. cooling (MW)

d. wastewater treatment-liters/day

e. solid waste processing-kilograms/day

f. potable water-liters/day

heat to power ratio (average expected)

energy source

expected payback period

Type and size of user

a. residential (dwelling units)

b. residential (square area-m^2)

c. commercial (square area-m^2)

d. industrial (thermal + elec.-MW)

14. Other Related Projects *(Titles)*

15. Additional space for Purpose of Project

16. Additional space for Status and Results

USCOMM NBS DC

APPENDIX C

PROJECT PROGRESS/EVALUATION REPORT FORM
FOR THE
CCMS-MIUS PROJECT
August 20, 1976

(Prepared by the Data Format Committee)

PROJECT PROGRESS/EVALUATION REPORT

Identification No. ________
Secretariat Use Only

Part I , GENERAL

1. Official Title of Project

2. Date this form completed ________ ________ ________
   Day Month Year

3. Principal Investigator (Name and Complete Mailing Address

4. Location(s) where project is performed (if different from above)

5. Type of organization listed in Question No. 3 (check the one or combination that most nearly describe your arrangement)

   Private Industry ________

   Non-Profit Laboratory ________

   Trade Association ________

   National Government Agency Laboratory ________

   University ________

   Regional/State/Local Government ________

   Utility ________

6. Is this project intended as (check appropriate one(s), if a combination show the dominant one by the numeral 1 and the lesser by the number 2)

   (a) a demonstration ________

   (b) a verification of a technical design ________

   (c) a pilot plant ________

   (d) a technical laboratory ________ or

   (e) an operational system ________?

7. Are you aware of similar projects in existence or under consideration? Can you supply a complete mailing address of the person to contact?

8. Are there any restrictions on the disclosure of this information? Explain.

9. Component mix of System or Subsystem

a. Type of Buildings Services

	Totals Per Type			
	# Units	Population[a]	Area (m)^{2}[b]	Status[c]
1. One family detached				
2. One family attached				
3. 2 to 4 families				
4. 5 to 9 families				
5. 10 to 19 families				
6. 20 to 49 families				
7. 50 or more families				
8. Schools				
9. Offices				
10. Shopping Mall				
11. Industrial				
12. Recreation				

b. Are room temperatures individually controlled by thermostats?

________ Yes ________ No

c. What is the average or typical ceiling height? ________meters

---

[a] Specify which, design or actual population.

[b] The area that is heated and cooled.

[c] Indicate with: 1 = Exists 2 = In Construction 3 = Conceptual

10. Features Included:

	Yes	No
a. Water Reuse		
b. Thermal Energy Storage		
c. Tie With Local Electric Utility		
d. Building Design Change for Thermal Energy Efficiency		
e. Sludge Burning		
f. Water Conservation		
g. Energy Recovery		
h. Materials Recovery		

11. Utility Services Provided:

	Yes	No
a. Electrical Power		
b. Space Heating		
c. Space Cooling		
d. Potable Water Heating		
e. Wastewater Treatment		
f. Solid Wastes Processing		
g. Potable Water Supply		
h. Industrial Process Heating		
i. Industrial Process Cooling		

12. Thermal Characteristics of Building Envelope

Type of Building Construction	Frame	Masonry	Concrete	Attic	Sidewalls	Between Floors & Ceiling	Single	Double	Triple	Concrete Slab	Crawl Space	Full Basement	Number of Floors Above Grade	Number of Floors Below Grade
a. One family detached														
b. One family attached														
c. 2 to 4 families														
d. 5 to 9 families														
e. 10 to 19 families														
f. 20 to 49 families														
g. 50 or more families														
h. Schools														
i. Offices														
j. Shopping Mall														
k. Industrial														
l. Recreation														

Frame, Masonry, Concrete — Check the one that most nearly fits the major portion of the exterior surface

Attic, Sidewalls, Between Floors and Ceilings — Thermal Conductance (C) the gross rate of heat transfer, Σq, divided by the temperature drop, Δt

$$C = \Sigma q / \Delta t$$

Concrete Slab, Crawl Space, Full Basement — Type of Foundation, % of Area

Single, Double, Triple — Kinds of Windows or glass as a percent of the exterior surface of building (including roof)

13. Development Site Plans to Include:

    a. Development Schedule (if project not complete)

    b. Site Layout (show buildings, roads, and parking lots and buildings to be served by MIUS)

    c. Proposed or Actual MIUS Site

    d. Site topography

    e. Wooded Area

    f. Floodplain Data

    g. Site Distribution of Electricity and Thermal Energy Utility Plans

14. Characterize annual site loads by type, in relation to typical weather patterns, site building, occupancy and occupant characteristics.

    a. Brief description of type of climate, according to the Trewartha* worldwide classification system

    b. Mean daily and monthly dry and wet bulb temperatures (relative humidity may be used in place of wet bulb temperature)

    c. Number of degree - days of location:

        a. Heating ________

        b. Cooling ________

    d. Average and typical maximum monthly wind speed?

    e. Number of days of overcast in heating season? ________

       Number of days of overcast in cooling season? ________

15. f. What plant operation equipment (indicating and recording instruments) are installed and used to document the performance?

16. Does this project demonstrate a unique technology? If so give details.

17. What if any were the "institutional factors" that had to be overcome in order to have your project operational? (In addition to barriers occasioned by law, finance, business, or labor, the term also is applied to political, regulatory, social or psychological adjustments and changes.)

18. Please describe potential adverse environmental or ecological effects. Describe the instrumentation and methods used in making these determinations.

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* G. T. Trewartha, An Introduction to Climate (McGraw Hill: New York, 1968).

19. The predicted utility loads analysis of the project for heating, air conditioning, electrical power, potable water, hot water, sewage and solid waste including but not limited to the following load data:

  a. Design electrical peak demands in kilowatts

  b. Electrical consumption loads charted in daily, monthly and annual kilowatt hours

  c. Design, peak and average heating and cooling loads, charted

  d. The overall electrical load factor (expressed as a percent)

  e. The average water demand use (expressed in total liters per day)

  f. The peak water demand use (expressed in total liters per day)

  g. The solid waste generated by the MIUS Demonstration Development (expressed in kilograms per day)

  h. Average and peak sewage processing demand (expressed in liters per day)

20. Do you have any plans for reducing thermal and electrical peak demands?

21. What percent of the time has the system been able to meet its demands? ________. Explain why this is so and what corrections are planned.

22. Are you aware of similar projects in existence or under consideration? Can you supply a complete mailing address of the person to contact?

23. Are there any restrictions on the disclosure of this information? Explain.

Part II

Solid Waste Management

1. Give technical information on Solid Waste Treatment plant, and describe operation on basis of plant line diagrams o.a.

   a. Typical refuse composition as received (%)

   b. Methods for size and volume reduction employed for preprocessing of solid waste

   c. Material reclamation practiced.

   d. Percentage of reduction of refuse at incinerator by weight and volume

   e. Steam produced and consumed by plant

   f. Electricity produced and consumed by plant

   g. Give charted capacities of electricity and steam produced (daily, monthly, annual)

   h. How is recovered energy utilized by consumers?

   i. What are some of the other constraints on the system that have not been covered.

2. Give information on costs

   a. Conventional cost per ton of Solid Waste from pick-up to the nearest land fill site or common (municipal) incinerator

   b. Cost per ton of Solid Waste from pick-up to the incinerator

   c. If the tonnage of solid Waste collected per day is greater than can be incinerated, how is the excess taken care of and at what price per tonnage.

   d. The cost per ton of refuse incinerated, the total plant capital cost and yearly operaring cost.

   e. The actual cost per kW/h of electricity produced and heat (in Joules) supplied by the solid waste recovery system.

   f. What is the conventional cost of electricity and heat (steam) cost when purchased directly or indirectly.

   g. What is the cost of disposition of the incinerator residue.

Part III .

Liquid waste management

Give technical information on liquidwaste treatment plant, and describe operation ons basis of plant line diagram o.a.

1. Sewage	Influent Concentration	Effluent Concentration.
a. Biochemical-Oxygen Demand (BOD 5) mg/l	_____	_____
b. Chemical-Oxygen dissolved (COD) mg/l	_____	_____
c. Dissolved-Oxygen D.O. mg/liter	_____	_____
d. Total suspended solids	_____	_____
e. Detention time hours	_____	

2. Waste water.

   Give composition of waste water other then domestic waste if applicable.

3. Rain water.

   a. Is rainwater collected seperately.

   b. Give rainfall duration and intensity charted yearly.

4. Sludge.

   How is sludge disposited?

5. Garbage.

   Are garbage disposals prevalent?

6. Test.

   a. Describe test that are made.

   b. Give a general description of sampling techniques.

   c. Explain the methods and instrumentation used in these measurements.

Part III (Cont.) 7. Energy consumption.

- Electricity consumption charted per day ____________
- Fuel " " " ____________

8. Methane production

- Methane production charted per day ____________
- How is methane utilized
- Give recovered energy production charted per day ____________

Part IV.

ENERGY BALANCE MIUS vs CONVENTIONAL

	A Delivered Thermal Power Joules	B. Delivered Electric Power kWh.	C. Fuel energy Used Joules.
MIUS PLANT ENERGY CONSUMPTION;			
1. Boilers			
a. Supplementary Output Boilers	______		______
b. Solid Waste	______		______
c. Others			
2. Electric Generators			
Electric Power		______	
3. Other Misc.Components			
Thermal Power	______		______
Electric Power		______	______
4. Total Fuel Energy Consumption			______________
3. Thermal energy recovered from			
prime mover		______	
solid waste plant		______	
Sewage plant		______	
4. Total thermal power recovered		______________ ______	

CONVENTIONAL PLANT COMPARABLE ENERGY CONSUMPTION

	A Delivered Thermal Power Joules	B Delivered Electric Power KWH	C. Fuel Energy Used Joules
5. Heating	______	______	______
6. Air conditioning		______	______
7. Lighting		______	______
8. Solid Waste Treatment	______	______	
9, Liquid Waste Treatment	______	______	______
10. Potable Water	______	______	______
11. Misc. Thermal	______		______
12. Misc. Electrical		___	______
13. Total Fuel Energy used			______

14. Net savings 13 - 4 = Joules

Conventional will be defined as the best utility services system that could be installed at this site without a MIUS Plant.

The International System (S.I.) will be used exclusively* with the following recommendations:

Pressure	-	given in bar (10^5 pascal) so as to be close to the value in atmospheres.
Temperature	-	^oK
Energy	-	the Kw-hr (3600 Kjoule) will be used.
Energy Flow Rate	-	Kw
Solar Radiation	-	the intensity will be given in w/m^2, the hourly, daily, monthly or annual totals will be given in $kwhr/m^2hr$, $kwhr/m^2day$, $kwhr/m^2month$ or $kwhr/m^2year$.
Wind Speed	-	km/hr.
Mass Flow Rate	-	kg/hr.

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* According to the resolutions of the Conference Générale des Poids et Mesures, 1960.

APPENDIX D

COMMITTEE ON CHALLENGES OF MODERN SOCIETY
RATIONAL USE OF ENERGY
CCMS-MODULAR INTEGRATED UTILITY SYSTEMS PROJECT

DRAFT
STANDARD METHODOLOGY
FOR
MEASUREMENT OF PERFORMANCE
OF
MIUS TYPE OF PROJECT

Prepared by

Measurement Technology Committee
J.A.Knobbout, Netherlands, Chairman

JULY, 1977

STANDARD METHODOLOGY FOR MEASURING THE PERFORMANCE OF MIUS TYPE OF PROJECTS

I. INTRODUCTION

Reporting Systems

This document, which provides guidelines for measuring the performance of MIUS type of systems, is the third level of a three level reporting system developed by the CCMS-MIUS pilot project to facilitate and encourage the exchange of technical information among participating countries on MIUS type of projects, and to encourage the introduction of MIUS type of systems related to the required function (or mission) of the system.

The first level reporting system is an International Project Catalog which identifies the planned on-going and completed MIUS type of projects in participating countries. It provides sufficient information for one to understand the project, its objectives, approach, etc. Also given is the sponsoring and performing organizations and the principal investigator who can be contacted for further information.

The second level reporting system is the Project Progress/Evaluation Report. It is designed to provide guidelines for reporting the progress of a project on a periodic basis and to provide information and data for evaluation of the site served and the utility system.

General Background

The MIUS concept has emerged in the U.S. as an outgrowth of problems such as diminishing reserves of fossil fuels and water resources, degradation of the environment, inability of wastewater treatment facilities to keep pace with new construction and population growth, and a growing shortage of land for solid waste disposal near urban areas. Many of these problems have likewise impacted on many other countries, some more severe than others. Many European countries have faced the problem of obtaining a sufficient supply of reasonably priced fossil fuels much earlier than the U.S. and as a consequence have made widely accepted advances in district heating, combined cycle generation of power and steam, combined production of heat and power and total energy.

This gives rise for the need of all countries to share technology, research, and expertise in reducing these problems and to conserve the world's natural resources and non-replenishable fossil fuels through ample and more efficient utility services. The CCMS-MIUS Project is an answer to this need.

The various utility systems in Europe and North America which rely on the integration of two or more subsystems to produce services more efficiently than single utilities are defined by the CCMS-MIUS Project as a MIUS Type of Project. (Refer to Section 2.3 of this report).

Severity of the Problem in the U.S.

Diminishing reserves of fossil fuels, particularly petroleum and natural gas in the U.S. and the continued reduction in their production have increased the U.S. dependence on high-priced imports of petroleum and to some extent liquified natural gas (LNG). The utilities there as a result have increased their rates, and in many cases have reduced the level or quality of services. In the midst of this seemingly irreversible trend demand for these same services again are on the increase.

During the winter of 1976-1977, one of the most severe winters in the U.S., a shortage of natural gas left many homes without heat in some states. Many industries dependent upon natural gas either had to switch to alternate fuels or shut down entirely. Future winters are not expected to be better.

Alternate sources of energy such as solar, coal and nuclear have their problems and will be slow to come into prominence. Although solar energy does not appear to have environmental problems associated with its use, it suffers from institutional rather than technical limitations. First cost limitations on construction finances and mortgages may inhibit the availability of hardware to utilize solar energy. Coal, which is the country's most abundant fuel has serious constraints in the way of even modest gains in coal demand. Barriers include restrictive air pollution regulations, potentially inadequate coal transportation systems, productivity declines in underground coal mining and too little research on coal mining and coal preparations.

The growth of nuclear power in the U.S. is behind schedule due to environmental problems and the question of safety. The promise of the breeder reactor is a long way from fulfillment.

The impact of the shortages and rising cost of fuel undoubtedly will affect the availability of housing and development patterns of communities. The trend has already been set. An increase toward a greater proportion of multi-family dwellings will be accelerated due to space conditioning and economic constraints. A shift in the location of new housing to scarce land resources nearer the urban and suburban population centers (partially due to transportation costs) will increase densities and will accelerate the multi-family trend.

Other factors which contribute to the lack of these utility services in the U.S. are the pressures of rapid population growth and the mobility of the population. The number of new families seeking housing is at an all time high. The high price of land in large metropolitan areas has led to an increased number of multi-family dwellings. Multi-family construction has represented as much as 50% of new housing starts in recent years.

In addition to the problems of energy supply, the lack of other utility services is limiting the orderly growth of communities. There are serious problems related to the adequate treatment and disposal of liquid and solid wastes. This is evident by the advent of moratoria on sewer hook-ups and construction throughout the U.S. With these problems in mind the U.S. Department of Housing and Urban Development embarked upon an important research effort, the development of the MIUS, which provides improved means for furnishing essential utility services for residential communities through integration of these functions.

Severity of the Problem in European Countries

In Europe one meets quite different situations with regard to the structure of energy production and consumption. Some countries import 80% or more of their energy consumption, e.g. Sweden and Denmark, but other countries have large quantities of natural gas available or hydropower, coal and in future oil from the North Sea. The prices and the structure of the prices of the energy carriers differ greatly, but are generally higher than in the United States. In the last decade all European countries have followed a policy to keep the cost of energy relatively low.

The actual prices depend strongly on the local situation, geographical location, availability of fossil fuels, etc.

This has, among other things, caused an increase in the direct electrical heating of houses in a number of countries while others have not considered heating an acceptable application of electricity.

In Europe there are areas with a high population density, and in an early stage district heating and centralized heating systems with a high power have been realized.

A growth of the population in the coming decade is foreseen and also a change in life style which will lead to higher standards of comfort and more freedom of working hours, etc. The governmental attention to create an acceptable environment has resulted in a great number of rules and laws which in general increase the price of energy. The growth of the yearly energy consumption is higher than was foreseen and seems not to be influenced by the increase of the price of oil. The same holds for the prices of coal, gas and electricity as most countries follow a policy to relate the prices

of electricity, etc. to the world oil price. The introduction of nuclear energy is well behind the scheme that was foreseen. It is expected that Europe in the future will be more dependent on coal for the direct burning for the production of electricity and heat and/or gasification of coal to produce gas as an energy carrier. The countries which now depend on natural gas as an energy carrier are expected particularly to be more dependent upon coal gasifications. Also from a point of view of flexibility and availability the use of coal is preferable.

In general, it is expected that the prices of energy will rise steadily and the rules for the pollution control will be more stringent, and that the foreseen scarcity of fossil fuels will influence the energy policy of the European countries. All these factors lead to the application of more integrated systems of the MIUS type on a small scale, as well as on a large scale. Up to now, mostly the incentives to install a MIUS (in the most simple form of a total-energy-system) are the financial aspects, but from the above it can be seen that in the near future other incentives will also influence the decisions which will result in a broader and enlarged application of the MIUS concept in Europe.

MIUS Concept

The MIUS recycles energy by packaging into one processing plant as many as six utility services necessary for community needs and development. They are electricity, space heating and water heating, air conditioning, wastewater treatment processing, solid waste processing and residential water purification. Conventional methods of generating electricity reject about 65% of the energy input in the form of excess heat. MIUS recovers better than half of this rejected energy and uses it for space heating, air conditioning, water heating, and to improve wastewater treatment efficiency.

An additional 5-10% fuel savings is accomplished by recycling solid waste for its energy content.

The overall objectives of the MIUS concept particularly in the U.S. are to:

- Provide utility services in an improved manner with advantages in total cost, decreased environmental impact and increased efficiency in the utilization of natural resources;
- Provide utility service capacity at a pace equal to the rate of growth of the new development.
- Make land available for development in areas that are not being serviced by conventional utilities.

Definition of the Problem from an international point of view.

There are many potential MIUS type of projects. There are various approaches to project comparison, each with its associated data requirements. There are inherent difficulties in international technical information exchanges such as differences in terminology, computational analysis and measurement procedures. If the first two differences are made uniform and standardized, one can systematically resolve the latter. The major overall constraints are limited time and the fact that the technical experience of each country is based on their particular measurement procedures with which each is familiar but which may vary from country to country.

The accuracy of a comparison of two MIUS types of projects is dependent upon an awareness of the environment and constraints under which each is operating and of the limits of measurement methods which monitor each. For many real time monitoring is possible. However, due to cost or availability, manual and/or sampling methods can provide significant amounts of information which may be factored into performance evaluation equations.

Alternative Approaches

To compare the performance of two MIUS type of projects requires the acceptance of a common technical issue, approach, scope, and objective. Technical issues can be energy or fuel consumption, cost (capitol, operating and maintenance, social), pollution (land, water, air), reliability (component, subsystem, system, service) or others.

The approach could be a computational analysis of information obtained from the Project Progress/Evaluation Report or other specially-developed 'survey' mechanisms. Three levels of scope are apparent. A calculation procedure can be utilized to analyze two 'identical' integrated utility systems in different locations or environments. This is very narrow in scope and may not hold too much promise due to the relatively small number of 'identical' MIUS type of projects. MIUS type of projects of different processes, but with 'identical' or similar missions can be compared.

This scope allows an additional two types of evaluations. An example of the first type of evaluation is the comparison of the power generation and thermal (heating, cooling, hot water) subsystems of a complete MIUS to those of a 'Total Energy' plant with a new conventional central power generating station and a new conventional district heating system to determine the benefits of integration. The third and broadest scope allows the comparison of MIUS type of projects of the different missions and of different processes. This level of concentration would permit assessment of different approaches to utility services as to which saved the most energy or which polluted less, for example, per dollar of investment, per unit of capacity or per dwelling unit served.

These evaluations of the performance of two MIUS type of projects can have many objectives. They are: conservation (fuels, energy, materials, natural resources), better or more reliable residential utility services, cost reduction (initial cost, operating cost, social costs), less environmental degradation due to residential construction and its support utilities, fewer residential construction moratoria due to lack of available utility services.

II. Purpose

a. End purpose

The purpose of this document is (1) to provide a standard methodology that will be useful to administrators, engineers, economists, investors, regulatory authorities and potential users in measuring the performance of a MIUS type of project, technically, environmentally, economically and institutionally, (2) to provide guidelines for acquiring data considering the various systems, subsystems and equipment, their complexity and the various levels of measurement for a given application or need, and (3) to provide a format for reporting data that will be comprehensive and application to all MIUS type of systems.

This standard methodology will apply to an operating system, a demonstration facility or a pilot or prototype facility. It could also apply to a laboratory model. The basis developed herein will be sufficiently broad that it can be applied to all MIUS type of systems whether it be a total energy system, a complete MIUS with five utility services, or a solid waste processing system that recovers heat for either producing steam to generate electricity or to heat hot water for space heating purposes.

This standard methodology will be applicable as a final report which provides a complete compilation of data over the entire testing period or as an interim report compiling data over a specific data period.

This standard methodology will allow professionals from different backgrounds and cultures to be able to make logical interpretations and objective decisions concerning MIUS type of systems.

Of major concern is a methodology that will facilitate and encourage the exchange of information among participating nations. The standard methodology will require that data be specified in standard international units, such as units in the SI metric system. The use of standards only accepted in a particular country will be discouraged.

Another consideration is that the data collected will be sufficient and of such a nature that one MIUS type of system can be compared with another, on a national as well as international level. The practice encountered up to now is mostly "user" (broad scope) oriented. This means that in many situations the data collection system has an insufficient level to reach a fruitful comparison of MIUS systems. Adequate data collection becomes a key factor in view of the various types of power generating prime movers such as diesels, gas turbines, steam turbines, combined cycle generating equipment, etc., and various means of treating wastewater and

processing solid waste and in view of the various types of fuel which are commonly used for power generation (coal, natural gas, and nuclear fuel).

Also to be considered is the various objective(s) of the particular MIUS type of project. This can heavily influence the different MIUS systems in the set up and particularly in the data collection and instrumentation. The prime objective of a project may be to conserve energy, to reduce cost to the consumer and increase profit for the investor, to reduce air and thermal pollution, to provide needed utility services either too costly, of poorer quality from other sources or even non existent as a result of local moritorium.

b. The scope of this document

This document contains the first phase of a program to develop a standard methodology in measuring a MIUS type of project.

This phase includes:

- the analysis of a MIUS built up from a number of function oriented subsystems and related to the measurements.

The following aspects are considered:

  ° the main elements of the subsystem

  ° the interface

  ° the main input and output flows

  ° the most important parameters to be monitored.

- the instrumentation

- the influence of the objectives on the instrumentation

- the data acquisition system

III. Approach of the technical problem

For the formulated objectives, how diverse they are, information about the systems and the behavior of systems is required. This only can be found by installing adequate instrumentation in the system. From a general MIUS concept many types of installations can be realized and can differ extensively in regard to the objective of the system, capacity of the utility services, level of integration, the extension of the complex in which the utilities are used, control system, etc.

In all these situations, information should be generated by instrumentation and in general, the instrumentation is directly related with the objective or the purpose of the information. It is therefore considered relevant to give an overview, even in abstract form, or in details of the possible MIUS systems. It is the aim of this report to present the basic ideas in relation to a MIUS concept.

The system approach has been chosen in order that a MIUS can be seen as a total system, which is function-oriented and composed of a number of subsystems where each has a specific function, and where the subsystems are related to each other, the environment and the consumers of the generated utilities.

In the systems approach it is not important in what technical way each function is accomplished.

a. The MIUS as a total system

The MIUS is considered as a blackbox which from a certain input generates a number of utility services required by the consumer. In the blackbox streams also are generated which can be considered as undesirable flows but which have to be managed, taking into account for instance aspects such as pollution control, etc. In figure 1 a number of the streams are shown and the input and output are evident.

Not only is the MIUS system essential, but also the buildings as a system are important. The static and dynamic response to changing conditions influence the MIUS but a direct feedback from the buildings, or more general the consumer to a MIUS system is not foreseen. Of course the wastewater and solid waste generated are inputs but they are not considered feedback in the sense of a control system. In this approach, it is important to define the boundary between a MIUS system and a consumer. From a general viewpoint it follows that the boundary should be defined by the responsibility of the owner and/or operator of a MIUS system. Another approach could be at what stage or place the cost charging of the consumer is measured. In practice it can be with or without a transport system between the MIUS and the consumer. Specially in the situation where the transport lines are rather long and/or where a decentralized MIUS system

is in operation which consists of a number of centers which generate the utility services. It is important to treat the transport as a subsystem. The latter concept is the last step to a more integrated district heating which is generally not considered as a full-class MIUS. In the following discussion attention will be given to the transport as a subsystem also.

b. Subsystems

In a MIUS a number of subsystems can be recognized and a specification derived for each function.

The following subsystems are recognized:

1. heat/power electricity generation
2. production of domestic hot water
3. production of hot water for heating purposes
4. production of cold water for air-conditioning
5. solid waste processing
6. waste water treatment subdivided into an aerobic treatment and an anaerobic treatment)
7. production of potable water
8. disposal of waste heat
9. storage systems, more specially thermal storage systems
10. disposal of effluent system including transport
11. disposal of ash system including transport
12. sludge disposal including transport
13. control system for the optimization of the MIUS

IV. Description of subsystems

In this chapter the following will be given for each subsystem:

- a description of the function
- the elements of the subsystems
- the characteristics of the main inputs and outputs of the system, which are the places where the sensors for the data acquisition have to be installed
- the interface with other systems to present the transfer of the energy or utility and the transfer of the cost
- the parameters to be monitored for determination of the performance as far as possible.

The parameters to be monitored depend on which information is desired. Only the viewpoint from the MIUS concept will be followed here. The most important aspects are as follows:

- the energy aspect, distribution of the energy flow and the different kinds of energy
- the economic aspects, costs of the subsystem and the performance, fuel consumption, etc.

- the pollution aspect. It is not intended here to present rules and regulations regarding the pollution, but it is necessary to underline which output of subsystems can be influenced by the rules regarding pollution

1. Heat/power electricity generation

Function: to convert fuel to electricity and heat in the form of:

- hot water for heating
- hot water for domestic hot water
- steam

In this definition the type of prime mover is not relevant and the definition applies to a gas engine as well as a steam or gas turbine as prime mover.

Elements of the subsystem:

- the prime mover
- the heat exchangers
- the exhaust gas heater
- oil cooler
- the electrical generator,

with their controls

with the cooling and controls

Interface with other subsystems or environment:

- electricity distribution
- flow of hot water to:
  - . heat pump
  - . heat exchangers
  - . chiller
  - . air cooler
  - . solid waste drier
  - . effluent digester

Main inputs and outputs and their characteristics:

- fuel flow
- electricity output
- flow of water for cooling
- flow of exhaust gases
- noise production

Characteristics:

- heat value of fuel
- temperature of cooling water
- temperature of exhaust gases
- voltage
- electrical load

Monitored parameters (most important)

Object: to control the performance

- fuel consumption
- flow of cooling water and temperature in-out
- temperature of exhaust gases
- composition of exhaust gases (pollution)
- output electrical power (and quality)

1a. The stream or hot water boiler as a heat/power generation system with zero power generation.

Function: to convert fuel to heat in the form of hot water or steam

Elements of the subsystem

- the boiler with burner, feedpump and control system
- the preheating of the fuel (if required)
- the feedwater treatment

Main input and outputs and their characteristics

- fuel flow
- flow of feedwater
- flow of hot water or steam
- flow of exhaust gases
- heat value fuel

Characteristics

- temperature of feedwater
- temperature, pressure of steam
- temperature of heated water
- temperature of exhaust gases

Interface with other subsystems or environment

- flow of hot water or steam to:

  . heat pump
  . heat exchangers
  . chiller
  . aircooler
  . solid waste drier
  . effluent digester

Monitored parameters (most important)

Object: to control the performance

- fuel consumption
- flow of feedwater and temperature in and out
- steam pressure and temperature
- temperature of exhaust gas
- composition of exhaust gas (pollution)

2. Production of domestic hot water

Function: to produce hot domestic water

Elements:

- heat exchanger with control system
- transport pump
- heat pump (if the temperature is too low and an excess of power is available)
  (Remark: it is not realistic to suppose that a thermally driven heat pump will be used).

Main inputs and outputs and their characteristics

- domestic water flow
- electricity consumption of heat pump and transport pump
- hot water flow for the heating of the domestic water
- flow of steam and condensator

Characteristics

- temperature of heated water in and out
- temperature of heating water in and out
- pressure and temperature of steam and temperature condensator

Interface with other systems or environment

- transport system (domestic hot water) or consumer
- return low temperature cooling water pipeline
- RHW heat exchanger

Monitoring parameters (most important)

Object: to monitor the performance

- flow and temperature of heating water
- flow and conditions of steam
- flow and temperature of domestic hot water

3. The production of hot water for heating purposes

Function: To produce hot water at the desired temperature and flow for the heating of the building.

Elements of the subsystem

When the hot water from the subsystem 1 is directly used this subsystem contains only the circulation pump as element. In a system with a heat exchanger as separating element the elements are:
- heat exchanger
- transport pumps
- a heat pump
  (this opens the possibility to balance optimally between heat and power production).

Interfare with other subsystems or environment

- flow of hot water to heat pump
- flow of hot water to customer
- cooled water to subsystem 1

Main input and output and the characteristics

- flow hot water for heating
- flow hot water to heat exchanger or heat pump
- electricity for circulation pump and heat pump

Characteristics
- temperature of water from and to subsystem 1
- temperatures of the heating water

Monitored parameters (most important)

Object: to control the performance
- water flow and temperature of heating water
- water flow and temperatures of the water from subsystem 1
- electric power consumption (heat pump)

4. The production of cold water for airconditioning

Function: The production of chilled water for the airconditioning installation.

Elements of the subsystem

The main element is the chiller. This can be a mechanical or thermally driven refrigeration installation or a combination. Pumps for the circulation of cooled. Pumps for the circulation of cooling water.

In most situations the mechanically driven chiller is equipped with an electric motor. For large installations a directly driven (gas engine or turbine) refrigeration installation is appropriate and are considered as elements of the subsystem.

Interface with other systems or environment

- flow of chilled water to the consumer
- flow of condensate to the subsystem 1
- flow of cooling water to the wastewater cooling subsystem
- flow of exhaust gases
- flow of hot water to the subsystem 1

Main inputs and outputs and their characteristics

- chilled water flow
- flow of cooling water from condenser
- hot water flow (thermally driven) a steam flow (flow condensate)
- fuel flow (gas engine-turbine as directly coupled with a refrigeration installation)
- electricity power input
- flow of exhaust gas from the gas engine-turbine

Characteristics

- temperature of chilled water
- temperature of cooling water
- heating value of the fuel
- temperature of the exhaust gases

Monitored parameters (most important)

Object: to control the performanae
- flow of chilled water and temperatures
- flow of hot water and temperatures
- flow of condensate, temperature and steam conditions
- flow of fuel and heating value (from fuel company)
- electricity consumptions
- flow and temperature of cooling water
- composition of exhaust gases (pollution control; thermally driven heat pump)

Remark: the refrigeration systems decide which of the mentioned flows has to be monitored (or exists).

5. Solid Waste Processing

Function: To convert solid waste to ash, under production of heat.
Remark: Depending on the caloric value of the solid waste extra fuel has to be added. Another possibility is to pyrolyze the waste.

Elements

- the storage bunker(s) for the storage of the waste
- the collecting installation to transport the solid waste to the bunker
- the drying section to dry the waste when excess heat is available
- the air ventilators to generate the airflow for the drying of the waste
- the solid waste burner and boiler
- the exhaust gas cleaning system of the boiler
- the ash transport and storage

Interface with other subsystems or environment

- ash disposal subsystem
- the complex of buildings (flow of solid waste)
- the production of hot water system

Main input and output and the characteristics

- flow of hot water (or steam) to or from the main hot water pipeline
- flow of ash to the ash disposal subsystem
- flow of solid waste from the consumers
- flow of exhaust gases from the storage/drier of the solid waste and the waste disposal boiler

Characteristics

- temperature of the hot water to and from the subsystem
- temperature of feedwater and pressure, temperature of steam (if steam as energy carrier is used)
- heating value of the waste; humidity of the waste
- temperature and composition of exhaust gases

Monitored parameters (most important)

Object: to control the performance.
- flow of hot water and temperature in-out
- flow of air, temperature, humidity of drying air in and out
- flow of air to boiler, temperature exhaust gases and composition (pollution control)
- flow of solid waste

Remark: Since the disposal of the waste is the primary object of the system, the thermal performance is of secondary importance.

6. Wastewater/sewage treatment

Function: To digest the sewage and wastewater so that the effluent and the sludge can be discarded.
Remark: The 2 main processes are the aerobic and anaerobic digester. The secondly mentioned process requires a closed digester.

Elements

- pretreatment/action(mechanical separation of water and large objects)
- digester with air circulation (aerobic, open digester)
- after treatment installation (physical processes as dephosphating)
- digester without air circulation (anaerobic) and methane production
- cleaning installation for the methane (separation CO_2, H_2S, etc., if necessary for the smaller units not relevant) and not for the situation where the gas is directly fed to the gas engine.
- the installation for the separation of effluent and sludge (sludge decanter).

Interface with other subsystems or environment
- the complex of buildings (flow of wastewater generated)
- the sludge disposal and effluent disposal subsystems
- the subsystem power/electricity generation (for the usage of the generated methane in the anaerobic digester).

Main inputs and outputs and their characteristics

- flow of wastewater/sewage
- flow of effluent
- flow of sludge
- flow of methane (anaerobic treatment)
- flow of air in the anerobic treatment

Characteristics

- composition of effluent (pollution) and temperature
- composition of wastewater and temperature
- percentage of water in the sludge

Monitored parameters (most important)

Object: to control the performance
- flow of effluent and composition
- flow of wastewater/sewage and composition
- flow of sludge and percentage of dry material

Remark: Since the disposal of the wastewater is the primary object of the system, the production of methane may be considered of secondary importance.

7. Potable Water Production

Function: To produce potable water in sufficient quantity taking into account the rules, regulations, etc and to transport the water to the consumer (Remark: the storage of potable water is not part of this subsystem).

Elements of the subsystem

There are a number of processes which can produce potable water, the choice depends on the quality of the available water. There are so many possibilities that it is considered unrealistic to produce an overview in the form of the main elements of the processes.

Interface with the other systems and environment

Here the same remark can be made as has been done for the elements. The main interface between this subsystem and the other subsystems is the interface with the consumer.

Main inputs and outputs and their characteristics

- intake of untreated water
- potable water output

Characteristics

- composition of the water, chemical and biological

Monitored parameters

Object: to monitor the performance
- flow of the incoming water
- flow of potable water
- stored water
- quality of in and outflowing water

8. Transport System

Function: To transport the generated utilities from the relevant subsystems from the MIUS to the consumer.
Remark: In the case of long distance between the MIUS and the consumer or the decentralized multi-MIUS system it is practical to consider the transport as a separate system (due to the losses, more special heat losses).

Elements

1. Transport of electricity
   - Main distribution to the consumer or central connection of consumer (this will mostly be a low-voltage system without transformers)

2. Transport of hot water and/or chilled water for conditioning purposes.
   - Insulated pipelines
   - Transport pump
     (the possible heat exchanger between this system and the consumer heating or cooling system is considered to belong to the subsystem "Consumer").

3. Transport of hot domestic water
   - Insulated pipelines
   - Pumps

4. Transport of steam for heating purposes
   - Insulated pipelines for steam and condensate

5. Potable water
   - pipelines
   - transport pumps
   - storage of potable water

Main inputs and outputs and their characteristics

1. Electricity
   - electrical energy flow

2. Hot or chilled water (conditioned water)
   - flow of water (there are no water losses)

3. Domestic hot water
   - flow of hot water

4. Steam for heating purposes
   - flow of steam condensate

Characteristics

1. Electricity
   The voltage and frequency of electricity

2. Hot or chilled water
   Temperature of incoming and outflowing flows

3. Domestic hot water
   Temperature of incoming hot water

4. Steam for heating purposes
   - pressure of steam
   - temperature of condensate
   - the humidity of the steam

Interface with other subsystems or environment

- electricity to consumer
- flow of hot water or chilled water to consumer
- flow of steam to consumer
- flow ~f cooled heating water to subsystem No. 3
- flow of heated water to subsystem No. 4(chilled water)
- flow of condensate to subsystem No. 1 or No. 3
- flow of potable water to the consumer

Monitored parameters (most important

Object: to control the performance

1. Electricity voltage and current distribution, flow of energy

2. Hot water or cooled water for conditioning purposes
   Temperature of the water streams in and out and flows

3. Domestic hot water. Temperature of the water and flow of water.

4. Steam, steam pressure, flow of steam (in the form of flow of condensate) (quality of steam)

5. Potable water
   - flow of potable water
   - pressure of potable water systems
   - quality of potable water

9. Effluent disposal system

Function: to dispose the effluent of the subsystem 6.
Remark: There are many possibilities to dispose the effluent of the wastewater treatment. The choice out of the possibilities depends on the local situation and regulations, etc. It is not possible to give a detailed overview of the elements.

Remark: In some MIUS types of projects the effluent is used for the flushing of toilets, etc., in general, for functions which do not require water of "potable" quality.

Interface with other subsystems or environment

The most important factor is the flow as a function of time of the effluent and the quality of the effluent.

10. Disposal of sludge

Function: to dispose the sludge produced in the wastewater treatment.
Remark: There are a number of disposal systems, the choice of which depends heavily on the local situation and the composition of the sludge.

The main possibilities are:
- landfilling
- dewatering sludge and usage for agricultural purposes
- dewatering sludge and burning
- artificial drying of the sludge and landfilling or agricultural use or burning

Elements of the subsystem

1. Landfilling
   - transport of water and sludge to the land region where the landfilling is permitted.

2. Dewatering and agricultural use
   - dewatering installation
   - transport to farmers

3. Dewatering and burning
   - dewatering of the sludge
   - burner for the sludge (and storage of the sludge)

4. Artificial drying and/or landfilling, etc.

   - the dryer of the sludge to a low water content
   - the other elements are related to the further use of the dried sludge

Main inputs and outputs and their characteristics

- flow of the sludge
- flow of dewatering sludge
- flow of dryed sludge
- the separated water from the dewatering is recirculated to the waste treatment installation
- flow of exhaust gases of the sludge burning (pollution control)

Characteristics

- composition of the sludge
- water content of the sludge

Interface with other subsystems or environment
- flow of sludge to environment
- flow of exhaust gases of the burning of the sludge

Monitored parameters (most important)

Object: to control the performance
- the water content of the sludge
- water content of dewatered dried sludge
- composition of exhaust gases (pollution control)
- flow of the sludge
- flow of dewatered sludge
- flow of dried sludge

11. Disposal of excess heat

Function: To dispose the excess heat if required.
Remark: There are a number of possibilities as follows:
- dry air cooler
- cooling tower, wet or dry or hybrid system
- usage of cooling water
- usage of waste heat in general (agricultural application)
- miscellaneous uses outside the MIUS and the consumer

Elements

- air cooler
- ventilator with constant speed
- cooling tower wet/dry
- pump and heat exchangers (not with a dry cooling tower)
- heat exchanger
- cooling water pump

Main inputs and outputs and their characteristics

- flow of hot water
- flow of cooled water
- flow of steam and condensate
- air flow (to environment)
- cooling water flow
- noise production

Characteristics

- temperature hot and cooled water
- pressure of the steam and temperature of the condensate
- temperature and humidity of the air (in and out)

Interface with other subsystems or environment

- flow of cooled water to the heating system
- flow ash stream to the environment
- flow of heated cooling water
- flow of steam condensate to the heating system

Monitored parameters (most important)

Object: to control the performance
- flow of hot water and temperature in and out
- flow of condensate, steam temperature and condensate (doubtful)
- temperature and humidity of outside air
- water consumption of wet cooling tower (air flow through air cooler and cooling tower)

12. Storage system

Function: To store the utility for the purpose of availability storage for the management of the MIUS system as a storage of waste, etc. is not considered.

Elements

1. Electricity
   No storage foreseeen

2. Heated water
   - insulated storage vessel for water (to incorporate advanced storage systems as molten salts, etc.)

3. Domestic hot water
   - insulated storage vessel with varying level

4. Potable water
   - water tower

5. Storage of chilled water
   - storage system (exception: mostly in the form of an insulated water vessel or ice/water storage)

<u>Main inputs and outputs and their characteristics</u>

- flow of heated water
- flow of domestic hot water
- flow of potable water
- flow of chilled water
- flow of electrical power

<u>Characteristics</u>

the in and outgoing temperature of the water flow

V. INSTRUMENTATION

To perform measurements an instrumentation and a data acquisition system is required; here special attention will be given to the instrumentation.

The instrumentation can have different objectives and an important one is the safety of the installation and in section VI-2 this aspect is treated more in detail.

From a point of view of cost it is a necessity to have information on the performance of the system and the subsystems. This can only be generated by executing measurements as mentioned above. The instrumentation, the characteristics of the sensors of the instruments and the data acquisition should be in accordance with the function or mission of the information generated by the measurements. It has to be underlined that not only are the characteristics of the sensors important, but also the way the sensors are mounted.

The instrumentation of an installation is a very well known and very extensive field. It is out of the scope of this report to present a survey of existing instruments, etc. The information about this aspect can be found in well known textbooks, codes of practice, etc. Here attention will be directed to more special remarks in relation with the MIUS system.

For the MIUS in relation to the instrumentation extreme conditions are not met and in practice not the highest level of accuracy can be reached due to the nature of the installation. In practice due to fluctuations, etc. a maximum accuracy of a performance measurement of 5% can be expected.

From the point of view of the MIUS the following aspects are of importance:

- the influence of time

- the characteristics of the instruments. The required characteristics are dependent on the required information from the MIUS system.

Influence of time

It is not always required or possible to perform continuous measurements. Examples are:

- Integrated energy flows (electricity, water, hot water for heat purposes, etc.)

- Control of pollution of the exhaust gases (boilers, prime mover, incinerator)

- Stock of fuel, wastewater, waste solids, etc.

- Composition of solid waste

- Composition of sludge (more special water content)

- Composition of exhaust gases from the point of pollution (partly continuous, partly only by sampling).

Another time element is the fluctuations of the different utilities and the importance of this factor depends on how far the demand and production should be instantaneously balanced.

In this three main levels are considered:

1. the electrical power production

2. the production of potable and more specially domestic hot water

3. hot water or steam for heating purposes and chilled water for the air conditioning.

From different points of view for instance, nominal capacity subsystems, connection with a community grid, the capacity of storages, optimization of the control system, the development of the trend of the demand curve etc., it is necessary to introduce the time factor in the choice of the instrumentation.

The demands which provide the most important information are:

- the peak demand and the duration of the peak demand

- the frequency of the peaks (see also annexe: reaction of the demand-system on the production system)

- the daily, weekly peaks and bottom demands

- the hourly, daily means of the demands and (or) production.

This time element influences in practice the choice of the instrument with a conventional recorder and in the more advanced systems the processor unit of the data acquisition system.

Characteristics of instruments

For the choice of the instruments the following aspects have to be taken into account related to the requirements deduced from the objective of the generated information:

- accuracy of the instrument
- reliability of the sensor
- repeatability of the measurement
- response time of sensor
- cost of instrument and sensor
- life time of sensor and instrument
- required minimum servicing
- integrating instrument with the DAS
- required sample size
- sensitivity to vibrations and noise.

a. Review of the situation

A short review is presented of the different classes of instruments of importance of the MIUS.

Temperature

The measurement of the temperature forms not a serious problem and there are no serious white spots (lack of required technology). Measurements of small temperature differences, for instance in heat flow measurements is a field which needs further development, more special in relation to accuracy, long life, reliability, and servicing.

Pressure

Measurement of pressure with the required accuracy is not a form of a problem.

Electric power

In this area no serious problems are encountered. From a point of view of load management and the installed capacity, special information is required on peak loads and trends in the picture of the fluctuations of the electrical load. The trend to measure by electronic means will influence the construction of the lay out of the instruments.

Flows

- flow of potable water and non-potable water. Usually only an integrating measurement is required and there should be no serious problem. Sometimes additional information is required on the peak demand.

- flow of domestic water. No problems are foreseen. Due to the higher temperature of the water the reliability of the instrument can be influenced.

- flow of oil. If small quantities of oil, are to be measured with practical accuracy (5%) the reliability of the existing instruments in regard to the life time is low. The balancing between accuracy, reliability, etc. of the instruments to measure larger quantities and regular flows is much easier. But still the continuous measurements of oil present a problem in the instrumentation. The measurement problem is very often aggrevated by the practice to over-dimensioned fuel pumps and the use of only a small part of the generated oil flow such that a backflow to the storage tank is required. The continuous measurements in this area form a problem. This measurement of consumption in the form of a total used quantity by measuring tank volumes, is one solution.

- flow of gas. When gas is the fuel then no serious problems are to be expected.

- flow of coal. If coal is used as fuel then the continuous measurements of the flow can only be realized if the consumption is high. When information is required, this can in practice only be done by weighing the input, which is a very accurate measurement. When a slurry coal feed will be introduced, there can rise some problems in connection with measurement of the carrier but for a MIUS this does not appear to be a realistic option.

- flow of chilled water and hot water for heating purposes (heat flow). The measurement of the flow of hot water or chilled water forms no problem. The problems arise due to the fact that the flows are measured as an input to calculate the heat flows, by multiplying the flow with the measured temperature differences between in

and outflow. This implies a continuous measurement of flow and temperature differences. Sometimes the temperature differences are small or fluctuating, resulting in a low accuracy. The cost of the instrument in relation to the required accuracy, reliability, long life time without recalibration, etc. makes this an area for further R & D activities. If the consumer has to pay directly for the delivered heat (or extracted heat), it seems feasible to install a number of heat flow sensors. New developments based on application of electronic devices in this area can be expected. One approach is to decentralize the measurements and utilize a centralized registration and computation to correlate the required output of a number of instruments.

- flow of steam (for heating). When steam is used for heating then problems are encountered in measuring the flow and the quality of the steam. The practical method to measure the flow is by measuring the return condensate flow and the pressure-temperature of the steam. Steam for the transport of the heat will mostly be used in the larger or more industrial oriented installations and in the situation that a higher temperature is required. In this situation a higher investment for the instrumentation can be afforded due to the high investment of the whole installation. Existent instruments meet the required specifications.

Performance tests

If it is necessary to test regularly the performance of the sub-systems to higher accuracy than can be reached with the installed instruments then extra instruments of high accuracy will be required. The reliability of such instruments over a long period is lower than the standard instruments and they need more frequent recalibration. A review of this area is out of the scope of this report.

Instrumentation in relation with some subsystems

Sewage Treatment (and wastewater treatment)

The treatment of the sewage in an aerobic or anaerobic digester needs special attention from the point of view of instrumentation. In the aerobic digester there are no special problems and the data for instance the B.O.D., C.O.D. of the sewage, the oxygen concentration, the percentage of dry material in the sewage or effluent, the water content of the sludge, are always gathered by a sampling process and not by continuous measurements.

In the anaerobic sewage treatment a more sophisticated instrumentation is required for the control of temperature, composition of the generated gas, control of the process as the sensitivity of mis-matching is high. The generated gas composition can be measured continuously but mostly a sampling is foreseen.

If an after treatment of the effluent is foreseen for pollution control (for instance dephosphating) continuous measurement for control and surveying is required.

Solid Waste Incinerator

The areas of problems in the field of instrumentation are caloric value of the waste, if required and the control of the composition of the exhaust gases in relation to pollution rules and special odor control.

Storage of Energy

To have information of the stored energy in a storage system should be of great help. The possibilities depends on the type of storage. When hot water or cold water is used then there is no problem, but problems arish if heat storage in the form of latent heat is incorporated in the system. Then the stored energy can only be measured by secondary information over a certain period which can introduce uncertainities and low accuracy.

VI. INFLUENCE OF THE OBJECTIVES ON THE INSTRUMENTATION

The objectives of the measurements including instrumentation and data acquisition systems depend strongly on the objective of the required information. Different classes in relation to the measurements can be recognized. Hereunder a short review will be given to clarify the influence of the user on this aspect.

1. Approach in practice

In the introduction already the relation is described between instrumentation and the investigations for national or international oriented energy research programs, the exchange of information, etc. Here more special attention will be given to the aspect of safety and the analysis of different approaches by the user.

2. The safety aspect

From the point of view of safety it is necessary to install components to prevent dangerous situations. It is also a necessity to prevent dangerous conditions in the installations, for instance too high or too low pressure, temperature, etc. and therefore it will be necessary to install measurement systems to indicate the conditions. More especially to indicate if the conditions are in the foreseen range or to indicate which condition is out of the normal range.

The extent of the measurement system depends on a number of factors as: the required personnel for the survey; the sensitivity of the components, mismatching of elements and effect of fouling, etc.

3. The objectives of the user

The point of view of the user of a MIUS system influences the measurement system including instrumentation and the data acquisition system. The user will take into consideration different aspects for instance:

- the energy aspects
- the economic aspects
- the environmental aspects
- the availability of the utilities generated by a MIUS

To insure the availability of the installation it is of importance that the installation will not be short of fuel or water, etc. This means that information should be available on the stock of fuel as oil, coal, etc.

Also it is necessary that there will be no overflow in the storage of ash and sludge, etc. These aspects are of importance for every MIUS system and will not be further mentioned. From the point of view of the user different levels of interest can be recognized as follows:

1. Cost oriented

   This can be considered as the lowest level and the only problem is the distribution of the cost for the bought fuel, water, etc. In this situation no attention is given to the efficient use of the fuel.

   As regards to the environmental aspects the pollution rules should be taken into account. This means regular check of boilers and prime movers, etc. Beside the instrumentation from the point of view of safety, etc. no special instrumentation is required.

   Remarks: Mostly this approach implies that the community consists of a small number of types of consumers.

2. Cost sensitive

   In this situation the consumer pays directly for the delivered utilities. More attention is then given to the energy aspect but not much attention is given to efficiency of the total system.

   The pollution aspect is related to the existing rules. In this situation instrumentation is required for the measurements of the different utility flows. This implies to install integrating instruments to measure the different flows.

   Remarks: This situation will be encountered when the types of consumers are quite different, for instance buildings, shopping centers, schools, etc.

3. Heavily cost oriented

   If the price for the utility is fixed and high, it is necessary to pay more attention to the performance of the MIUS system as a total and the subsystems. A more detailed insight in the total system is required. From the point of view of instrumentation besides integrating instruments to measure the energy flow to the consumer, it is necessary to have information of the flow to the different subsystems. With regard to pollution aspects the instrumentation depends on the existing rules in that area.

4. Heavy weight on the energy and economic aspects
In the situation that a heavy weight is given to the energy and economic aspects of the MIUS system it is necessary to optimize the total MIUS and the subsystems. This implies from the point of view of measurements that a more extensive registration of data is required. In this situation besides the integrating instruments for measuring the utility flows to the consumers and the different flows to and from the subsystems it is at least necessary to measure the total running hours of different subsystems. It is not unrealistic to suppose that a continuous registration of the most important conditions and flows is of a great help to the management of the MIUS.

The decision to install continuous registration depends on a number of factors and not at least on the total investment (capacity) of the MIUS.

From the point of view of pollution there is no difference between this and the above mentioned levels.

5. Heavy weight on the energy, economic aspects and reliability
If the reliability of the system is of high importance (in the situation of a high power MIUS) it is necessary to have more and more detailed information.

The frequency of measuring, if no continuous registration is foreseen, will be higher.

This implies:
- the installation of sensors of high reliability and repeatability and with a well defined and constant accuracy

- the extension of the registration with instruments indicating running hours, peak values of the conditions, peak values of utility flows, and some logic to indicate the spec. performance.

6. Optimization of the MIUS
In the situation of a high power MIUS, expensive fuels or restricted availability (rationed) of the fuels, an optimization of the total system and the balancing of the subsystem is required. This implies an extensive instrumentation and data acquisition system incorporating logic for the load management of the subsystems, the distribution of running time of components, etc. These requirements can be met by incorporating a microprocessor which will also generate the detailed information.

The required instrumentation and data acquisition system is so extensive and so specific that this is the field of a specialist and out of the scope of this exposé.

In general it comes rather close to the required instrumentation of a demonstration plant or for detailed R & D oriented investigations of a MIUS installation.

ANNEXE I

REQUIRED WEATHER DATA AND USED ORIENTED DATA

The MIUS is a function oriented system. For an evaluation of the economics of realized or proposed MIUS, the comparing of MIUS of the same type, to calculate the difference due to geographical differences it is necessary to have information about:

- the characteristics of the users of the MIUS
- the characteristics of the building(s)
- the meteorological conditions, more special weather conditions

The characteristics of the building(s) can be found by calculating or by measuring during the acceptance test of the installation, or from the data regarding heating, cooling, potable water consumption, etc. This needs no further special instrumentation.

The climatic conditions of the area are mostly known, but to register the weather conditions an adequate instrumentation and data acquisition is required.

Most important is the air outside temperature expressed as degree days or the highest and lowest daily temperature.

Less important but not of second importance are the following data:

- wind, velocity and direction
- solar radiation
- humidity of the air
- rainfall

From a point of view of measurements no special problems are encountered or are new instruments of advanced design required.

Remark: If solar collectors or wind generators are installed in the MIUS then measurement of solar energy and wind, respectively is of primary importance.

ANNEXE II

REACTION OF THE DEMAND-SYSTEM ON THE PRODUCTION SYSTEM

Transfer from one energy form to another meet final needs
The demand of different energy depends on the type of energy used. If a new energy is delivered the former demand is changed so to study the real demand of energy one cannot rely on the statistics of primary energy used.

In order to know exactly what are the needs of communities it is necessary therefore to have more precise data on the real and final purposes of the energy forms used, then it is possible to compare one evaluation to another one.

Statistical optimum and peak optimum

The demand of different energy depends as well on the form under which the enargy is delivered (exergie). But statistical data show that most of the time the peak value of the temperature used is very rare. So the data on temperature needed for the heating of communities must take into account more the statistical optimum than peak maximum.

Security for the demand

Any essential service must have security heat from a distance source delivered to users must be backed therefore by some security in the form of local generator. Annual checking of that generator may be done in conjunction with the main supply to meet the peak value of the heat needed.

ANNEXE III

REQUIRED DATA ON THE CHARACTERISTICS OF THE "CONSUMER" OF THE GENERATED UTILITIES

To compare MIUS projects and provide effective exchange of information it is essential to present the characteristics of the "consumer" of the generated utilities. This gives the opportunity to clarify differences of MIUS projects with identical missions.

Under the term "consumer" are considered the inhabitants of the building complex and the buildings itselves.

These characteristics include two main elements:

1. the life style of the inhabitants.
   This influences directly the demand of electricity, potable water and hot domestic water and to a lower degree the demand for non-potable water, hot water for heating purposes and chilled water for the air conditioning.

2. the characteristics of the building.
   This includes more specially the overall heat transmission under statistical as well as dynamical conditions.

The latter influences heavily the specification of the MIUS. When the building complex has been erected and the MIUS is operational the MIUS will, before acceptance, be tested in connection with the building complex. During this period it is possible to calculate the required characteristics from the measured temperatures and flows.

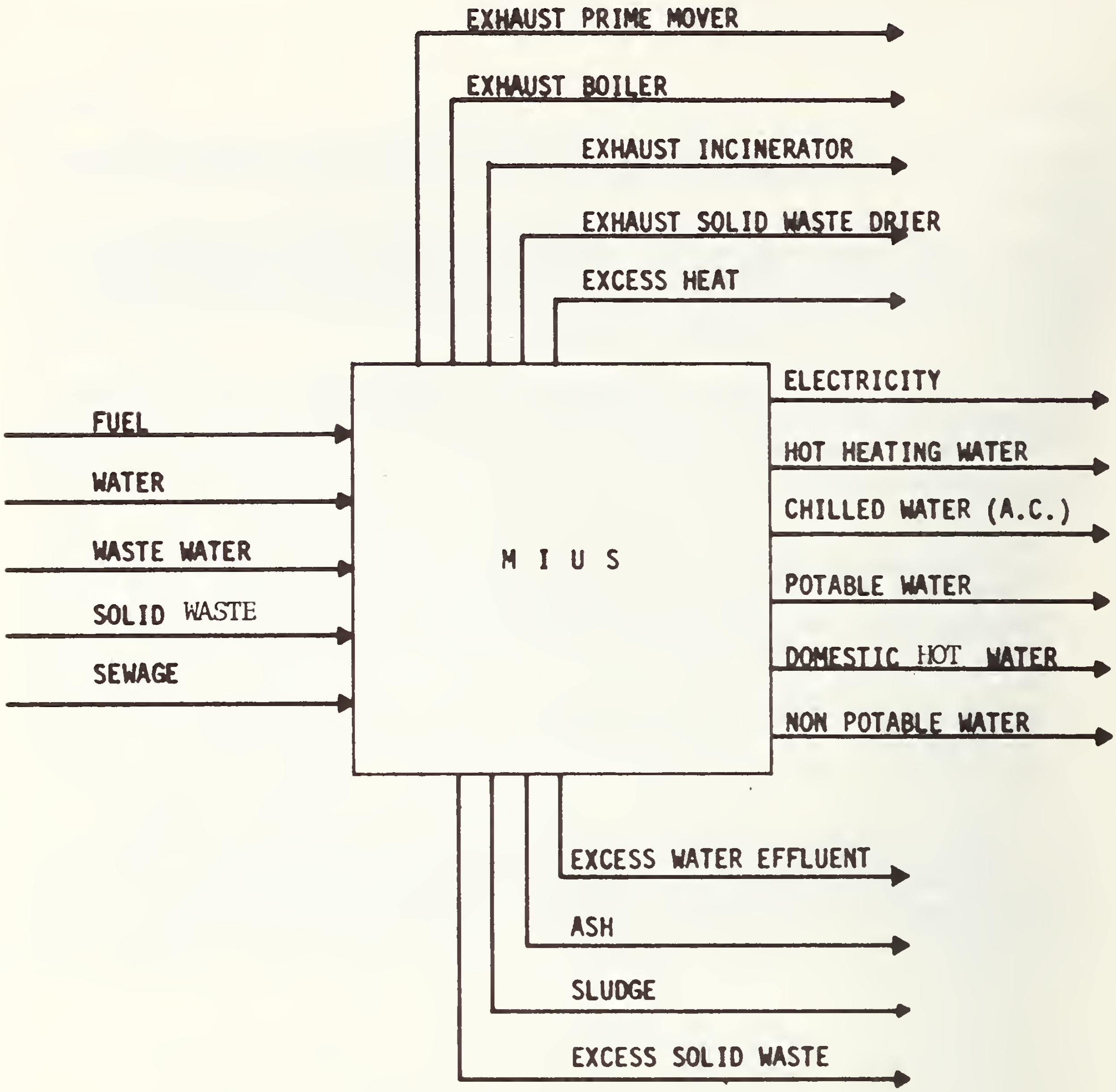

FIG. 1.: A MIUS AS A BLACK BOX

APPENDIX E

RESEARCH NEEDS IN INTEGRATED UTILITY SYSTEMS
FOR THE
CCMS-MIUS PROJECT
September 1, 1977

The CCMS-MIUS Project recommends new and additional areas of research which it views important in the advancement of integrated utility system technology. This research could enhance the technical, environmental and institutional feasibility of integrated utility systems and their cost competitiveness with conventional utilities.

In recognition of these research needs and in order that the CCMS Plenary might be apprised, the Chairman, Mr. Phillips, with Committee approval during the third CCMS-MIUS Project Meeting May 18-19, 1976 at EDF, Moret sur Loring, France, appointed the following as members of a working subcommittee (Research Needs Committee) to look at the research needs and identify their priorities.

Mr. Michel (Belgium), Chairman

Mr. Pillar (FRG) who will consult with Dr. Klein for a designated individual to represent FRG.

Mr. Cavros (U.S.)

At the fourth CCMS-MIUS Project Meeting, December 7-9, 1976 at the KFA, Juelich, W.Germany, Mr. Michel, Chairman of the Research Needs Committee presented a general framework on research needs for the combined production of heat and electricity (See diagram attached).

He identified five categories of research. They are 1. fundamental research; 2. technological research; 3. research and development of component and system research; 4. economics and 5. institutional and organizational. He further characterized the research needs as being either short, medium and/or long term.

He further identified problems as being associated with production (elec. and heat), distribution (transport, distribution, storage) and consumer (industrial-process and heat and commercial/residential).

Research needs

in the five categories of research are itemized below and are prioritized by the code: 1 - first (most important, 2 - second (very important), 3 - third (important). Note: Some research needs may be included in more than one category, some research needs are general and some are specific.

1. FUNDAMENTAL RESEARCH

a. (1) Stimulate research in new levels of new systems power conversion at all intervals (i.e. temperature levels) applicable to the available thermodynamic range. (For example: Multiple levels of power conversion).

b. (1) Reduce second law losses by controlling combustion through innovative design (i.e. maximize use of heat content in fuel).

c. (1) Improve and develop new materials for piping systems: particularly to reduce corrosion and increase durability.

d. (2) Develop high efficiency small steam turbines.

e. (3) Enhance Liquid Waste Treatment Processes by heat.

f. (3) Define Solid Waste Combustion Properties, Calorimetry, etc.

g. (1) Improve Metering Technology: hot chilled water and steam.

h. (1) Energy recovery from solid waste:

°Develop methods for the measurement, characterization and control of effluent stream pollutants.

° Develop methods for sampling, analysis and classification procedures for waste fuels.

°Examine and elucidate the mechanisms of corrosion of materials -of construction of fuel fired systems.

°Develop a uniform and equitable energy and resource recovery system economic analysis procedure.

°Develop materials handling processing and separating systems specific to waste fuel utilization.

°Establish a mechanism for the acquisition and dissemination of technology relating to waste to energy systems.

2. TECHNOLOGICAL RESEARCH

a. (1) Improve and develop coal utilization by small systems.

b. (1) Improve diesel engine exhaust heat recovery techniques and exhaust and stack heat exchangers. Also include heat recovery from boilers and other available sources.

c. (3) Investigate Diesel Engine Jacket Water Temperature, Wear Relationships.

d. (1) Study and Improve methods and design for retrofitting existing turbines to combined heat and power.

e. (1) Improve turbines that can adapt to both power and heat production with high energy efficiency.

f. (2) Improve absorption chillers with particular regard to use of recovered heat.

g. (3) Determine merits of water source heat pumps district systems.

h. (1) Develop large scale thermal storage techniques.

i. (1) Improve thermal distribution systems.

j. (2) Develop new trenching/piping/in-building heat systems development.

k. (3) Develop monitoring equipment (on-site use),control equipment, etc.

l. (3) Develop practical, low cost and reliable design techniques for protecting Data Acquisition System (DAS) equipment and instrumentation from voltage and current spikes and thus prevent possible catastrophic damage to equipment.

m. (2) Develop reliable low cost BTU meters.

n. (1) Also see lb.

o. (1) Improve Technology transfer.

p. (3) Utilize lower temperature waste water, by-products, etc.

q. (2) Study the technical economic and environmental feasibility under a variety of conditions of packaged incinerators used for heat recovery.

°Analyze manufacturers specification, theory of operation, input waste composition, methods of separating unacceptable material, performance analysis, actual design effectiveness and recommended design and operations modifications.

°Perform economic evaluation to compare all costs related to the purchase and operation of packaged incinerators.

°Analyze environmental impact on land, air and water.

r. (2) Materials of Construction for Packaged Incinerators.

°Extend burner rig test to include temperatures of 540°C, 650°C and excursions to 980°C.

°Study elemental compositions, chemistry, melting point and reactivity with lines materials at high, low and ambient temperatures.

°Develop fabrication and repair procedures for candidate liner materials.

°Investigate cycling effects (frequency range and rate) on liner materials).

°Study the effects of contaminants such as clay, calcia, magnesia, lead, zinc and silver.

°Design optimization studies.

°Perform full scale life tests of most promising materials and stability of weldments.

°Correlate heat content determination from Moisture-ash-free (MAF) basis to as-received.

s. (1) Improve treatment and disposal of Industrial and Municipal wastes by studying, performing or preparing:

°Physical properties of prepared refuse.

°State-of-the-act survey of waste storage and feeding mechanisms, non-thermal waste processes, thermal waste processes (direct combustion and indirect combustion), non-thermal sludge processes, combined sludge wastes thermal and non-thermal processes control technology for thermal processes.

°Characterization of hazardous and toxic wastes.

°A primer on combustion systems.

°Chemical and physical kinetics in waste combustion.

°A steam generator as a calorimeter.

°Energy recovery and emissions potential as a function of fuel homogenicly.

°Characterization of HCL emissions.

°Qualify and quantify ash in thermal processes.

°Delete correction to 12% CO_2

°New product design from waste disposal viewpoint.

3. RESEARCH AND DEVELOPMENT OF COMPONENT AND SYSTEM RESEARCH

a. (1) Improve and develop heat mapping and system planning techniques.

b. (1) Improve and develop combined power and heating station planning and operational analysis.

c. (1) Investigate technology assessment, particularly of District Heating (the technical environmental, societal and institutional impact of District Heating).

d. (2) Determine thermal storage operational requirements.

e. (3) Conduct spare cooling system planning.

f. (2) Same as 2i.

g. (1) Achieve full utilization of state-of-the-act in designing plants, instrumentation, components, energy transfer techniques.

h. (3) Same as 2 1.

i. (2) Improve the efficiency of boilers under part load conditions.

j. (1) Also see 2 s.

4. ECONOMICS

a. (1) Minimize piping and trenching costs.

b. (1) Perform study of comparative Life-Cycle cost of District Heating and Alternatives.

c. (2) Determine thermal storage costs.

5. INSTITUTIONAL AND ORGANIZATIONAL

a. (1) Determine the need for and legal and institutional feasibility of legal requirements forcing connection to District Heating Systems.

b. (2) Investigate need for regulation of District Heating Systems.

c. (2) Determine legal and institutional requirements for piping systems right-of-way: cellar easements, etc.

Research Needs
Types of Problems
a. Short Term
Medium Term
Long Term
b. Fundamental and Technological Research
c. Res.&Dev.
C_1, Components
C_2, Systems
d. Economics
e. Institutional Problems/Misc.

A PROD
A1 Cb E/Q
°Steam
°Gas plus second steam system
°Diesel/gas engine

A2 Q (Heat Only)
°Classical steam
°Nuclear (sm.bldg.)
°Heat Pumps(lg.&sm.)

B. Dist.System
B1 Transport
B2 Dist.
B3 Stor.

C. Consumer
C1 Ind. Process & Heat
C2 Com'l & Residential

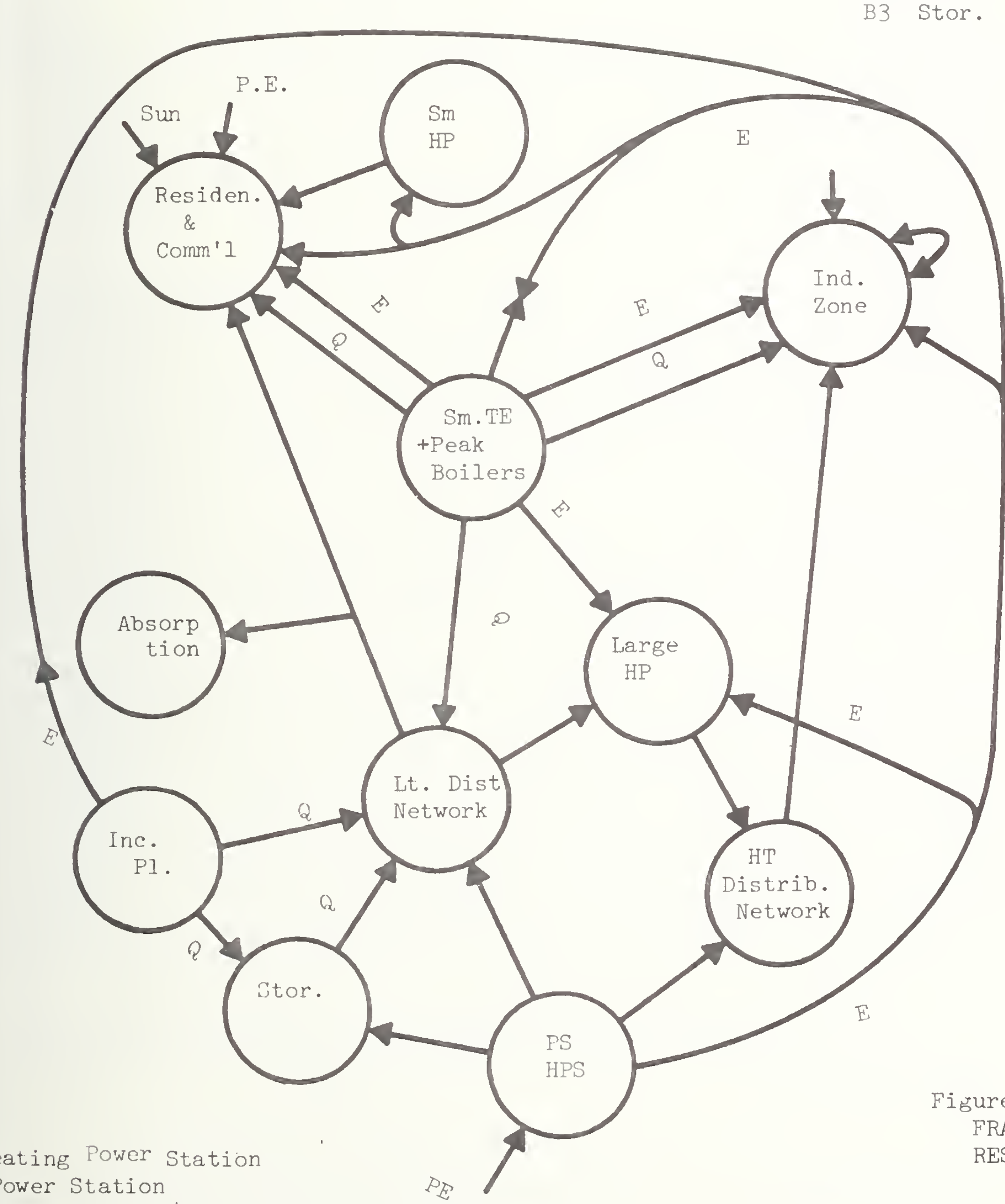

Figure 1
FRAMEWORK ON RESEARCH NEEDS

S=Heating Power Station
= Power Station
= Heating Plant/Heat Pump
OR = Storage
d = Industry
= Primary Energy

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)* This report by the Committee on the Challenges of Modern Society - Modular Integrated Utility Systems (MIUS) Project includes a description of the project, its objectives, the chronology of the project, a description of its activities and products, copies of its products (appendices A-E), and minutes of its meetings. This report further discusses the progress of each activity and product and gives the committee's recommendations, which call for the continuation of the project activities.
The objectives of the CCMS-MIUS Project were to identify MIUS Type of Projects in participating countries and to develop a mechanism for transferring technical data concerning these products to experts in the participating countries. The project had its first meeting in Brussels, April 10-11, 1975 and its last meeting in Turin, July 12-14, 1977.
The project produced a glossary of special terms, a project summary form the International Project Catalog, and a list of research needs in MIUS Type of Projects. It began development of a project progress/evaluation report, a standard methodology for measuring the performance of MIUS Type of Projects and a paper on "Incentives and Barriers". The glossary is expected to promote a greater understanding of terms unique to MIUS and the project summary form was developed to seek project descriptions for the catalog. The catalog identifies MIUS Type of Projects and the project progress/evaluation report provides progress of a project and technical information for purposes of evaluation and comparison. The standard methodology identifies the type of information required for measuring the performance of a MIUS Type of Project and the collecting and reporting of data.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

CCMS, CCMS-MIUS Project, Information Exchange, Integrated Utility Systems, International Information Exchange, MIUS, Report to CCMS Plenary

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